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

Volume I

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Lead Agency:	United States Department of Navy
Cooperating Agency:	National Marine Fisheries Service
Title of Proposed Action:	Atlantic Fleet Training and Testing Activities
Designation:	**Final Environmental Impact Statement/Overseas Environmental Impact Statement**

Abstract

The United States Department of the Navy (Navy) prepared this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114. This EIS/OEIS evaluates the potential environmental impacts of conducting training and testing activities in the Atlantic Fleet Training and Testing (AFTT) Study Area after November 2018 into the future. The AFTT Study Area is located within the in-water areas of the western Atlantic Ocean along the eastern coast of North America, in portions of the Caribbean Sea and the Gulf of Mexico, at select Navy pierside locations, within port transit channels, near select civilian ports, and in bays, harbors, and inshore waterways (e.g., lower Chesapeake Bay).

Three alternatives were analyzed in the EIS/OEIS:

- The No Action Alternative considers that the Proposed Action would not take place (i.e., the proposed training and testing would not occur in the AFTT Study Area).
- Alternative 1 (Preferred Alternative) reflects a representative year of training to account for the natural fluctuation of training cycles and deployment schedules that generally influence the maximum level of training that may occur year after year in any 5-year period. Alternative 1 also includes an annual level of testing that reflects the fluctuations in testing programs by recognizing that the maximum level of testing will not be conducted each year. This alternative contains a more realistic annual representation of activities, but includes years of a higher maximum amount of testing to account for these fluctuations. This alternative would not include the contingency for augmenting some weapon system tests and presumes a typical level of readiness requirements.
- Alternative 2 includes a higher number of training unit exercises and sonar hours than Alternative 1 but is still a reduction from the past. This alternative, reflects the maximum number of training activities that could occur within a given year and assumes that the maximum level of activity would occur every year over any 5-year period. Alternative 2 includes the testing of new platforms, systems, and related equipment. This alternative assumes that the maximum annual testing efforts predicted for each individual system or program could occur concurrently in any given year. This alternative includes the contingency for augmenting some weapon systems tests in response to potential increased world conflicts and changing Navy leadership priorities as the result of a direct challenge from a naval opponent that possesses near-peer capabilities.

The Navy analyzed potential impacts on environmental resources resulting from activities under Alternatives 1 and 2. This EIS/OEIS also includes an analysis of environmental effects from taking no action as a comparison to the effects of the Proposed Action. Evaluated resources included air quality, sediments and water quality, vegetation, invertebrates, marine habitats, reptiles, fishes, marine mammals, birds, bats, cultural resources, socioeconomic resources, public health and safety, and cumulative impacts.

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FOREWORD

The Draft Atlantic Fleet Training and Testing (AFTT) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) was released for public review and comment 30 June 2017 through 29 August 2017. Changes in this Final EIS/OEIS reflect responses to all substantive comments made on the Draft EIS/OEIS during the public comment period as well as Navy refinements to the Proposed Action. Additionally, the analysis has been refined to more accurately quantify the expected acoustic effects on marine mammals, taking into consideration animal avoidance or movement and Navy mitigation measures. Public comments are summarized, and the responses to them are included in Appendix H, Public Comments and Responses.

While most sections in the EIS/OEIS were changed in some manner between the draft and final versions, many of those changes entailed minor modifications to improve clarity. The key changes between the AFTT Draft EIS/OEIS and Final EIS/OEIS follow.

- Chapter 1 (Purpose and Need and Alternatives) and Chapter 2 (Description of Proposed Action and Alternatives):
  Reiterated that from the outset of this EIS/OEIS Navy and National Marine Fisheries Service (NMFS) have worked closely together, with an appreciation of each agency's respective purpose and need. Included additional clarifying language further articulating NMFS' distinct purpose and need, as well as further explaining their role in the development of mitigation measures that shaped the Action Alternatives.

- Chapter 2 (Description of Proposed Action and Alternatives):
  Annual levels of certain activities and resulting quantities of associated military expended materials and stressors were adjusted to reflect more accurate estimates of future training and testing needs and to correct errors. The general types and locations of training and testing did not change.

  Some of these changes affected the modeled marine mammal exposure results, such that some modeled exposures changed for both training and testing activities. Reduction of Undersea Warfare Testing Activities in the Northeast Range Complex reduced potential impacts from sonar and other transducers to Endangered Species Act (ESA)-listed whales and harbor porpoises. Modeled impacts (primarily behavioral response) increased overall for training with sonar and other transducers. For training activities with explosives, total estimated impacts decreased slightly for many species, especially behavioral impacts. Estimated impacts increased slightly for testing activities that use explosive for most species groups except mysticetes, which decreased slightly. Acoustic impacts from other sound sources such as air gun and pile driving remained unchanged from the Draft EIS/OEIS. Additionally, a few minor errors were identified and corrected. The updated exposure numbers are presented in Appendix E (Acoustic Impact Tables).

- Section 3.0 (Introduction to Affected Environment and Environmental Consequences): Tables were updated to reflect different annual levels of certain activities and resulting quantities of associated military expended materials and other non-acoustic and explosive stressors based on changes to Chapter 2 (Description of Proposed Action and Alternatives). Changes in the number of activities proposed also prompted updates to the tables describing the level of use of acoustic sources.

  Tables 1 through 8 identify the changes between the Draft EIS/OEIS and this Final EIS/OEIS for sonar and explosive usage during training and testing by alternative. Some of these changes affected the modeled marine mammal exposure results as described above in the Chapter 2 summary. Proposed sonar and other transducers remained mostly consistent between the Draft and Final EIS/OEISs, with minor exceptions shown in Table 1 and Table 2. The number of hours in the low-frequency (LF) 5 bin for training increased between the Draft EIS/OEIS and the Final EIS/OEIS because this sound source was added to the Submarine Sonar Maintenance activity in the Final EIS/OEIS. The amount of mid-frequency (MF) 3 sonar for both training and testing changed between the Draft EIS/OEIS and the Final EIS/OEIS because of the way this bin is reported. In the Draft EIS/OEIS the MF3 bin was reported as a count. However, to be more accurate, for the Final EIS/OEIS, the bin MF3 was converted into hours. Therefore, the overall amount of sonar in this bin did not change, however how the sonar is reported did change. The number of hours in the MF10 bin for training increased because this sonar bin was added to the Maritime Security Operations activity to support improvements on how this activity is conducted. The torpedoes (TORP) 3 bin for testing was added for the FEIS/OEIS due to a new requirement in the testing community that did not exist during the DEIS/OEIS.

  Proposed explosives use also remained mostly consistent between the Draft EIS/OEIS and this Final EIS/OEIS. Exceptions are noted in Table 3 and Table 4.

Table 1: Change in Annual Sonar and Other Transducers Usage during Training Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS

For Annual Training Activities								
Source Class Category	*Bin*	*Unit[1]*	*Annual Usage[2]*					
			Alternative 1			*Alternative 2*		
			Draft	*Final*	*Change*	*Draft*	*Final*	*Change*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	H	0	0	–	0	0	–
	LF4	H	0	0	–	0	0	–
		C	0	0	–	0	0	–
	LF5	H	0	9	+9	0	9	+9
	LF6	H	145–175	145–175	–	204	204	–
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	H	5,005–5,605	5,005–5,605	–	7,081	7,081	–
	MF1K	H	117	117	–	117	117	–
	MF3	H	49,188–49,227	2,078–2,097	-47,130[3,4]	49,265	2,116	-47,149[4]
	MF4	H	591–611	591–611	–	630	630	–
	MF5	C	6,708–6,836	6,708–6,836	–	6,964	6,964	–
	MF6	C	0	0	–	0	0	–
	MF8	H	0	0	–	0	0	–
	MF9	H	0	0	–	0	0	–
	MF10	H	0	870	+870	0	870	+870
	MF11	H	873–1,001	873–1,001	–	1,399	1,399	–
	MF12	H	367–397	367–397	–	596	596	–
	MF14	H	0	0	–	0	0	–
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	H	1,928–1,932	1,928–1,932	–	1,935	1,935	–
	HF3	H	0	0	–	0	0	–
	HF4	H	5,411–6,371	5,411–6,371	–	6,371	6,371	–
	HF5	H	0	0	–	0	0	–
		C	0	0	–	0	0	–

Table 1: Change in Annual Sonar and Other Transducers Usage during Training Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS (continued)

For Annual Training Activities								
Source Class Category	*Bin*	*Unit[1]*	*Annual Usage[2]*					
			Alternative 1			*Alternative 2*		
			Draft	*Final*	*Change*	*Draft*	*Final*	*Change*
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz (continued)	HF6	H	0	0	–	0	0	–
	HF7	H	0	0	–	0	0	–
	HF8	H	20	20	–	20	20	–
Very High Frequency Sonars (VHF): Non-tactical sources that produce signals between 100 and 200 kHz	VHF1	H	0	0	–	0	0	–
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	H	582–641	582–641	–	1,040	1,040	–
	ASW2	C	1,476–1,556	1,476–1,556	–	1,636	1,636	–
	ASW3	H	4,485–5,445	4,485–5,445	–	6,690	6,690	–
	ASW4	C	426–432	425–431	-1[3]	438	437	-1
	ASW5[5]	H	572–652	572–652	–	732	732	–
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	C	57	57	–	57	57	–
	TORP2	C	80	80	–	80	80	–
	TORP3	C	0	0	–	0	0	–
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	H	0	0	–	0	0	–
Acoustic Modems (M): Systems used to transmit data through the water	M3	H	0	0	–	0	0	–

Table 1: Change in Annual Sonar and Other Transducers Usage during Training Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS (continued)

For Annual Training Activities								
Source Class Category	*Bin*	*Unit[1]*	*Annual Usage[2]*					
			Alternative 1			*Alternative 2*		
			Draft	*Final*	*Change*	*Draft*	*Final*	*Change*
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged *swimmers*	SD1–SD2	H	0	0	–	0	0	–
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	H	0	0	–	0	0	–
	SAS2	H	0–8,400	0–8,400	–	8,400	8,400	–
	SAS3	H	0	0	–	0	0	–
	SAS4	H	0	0	–	0	0	–
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB1	H	0	0	–	0	0	–
	BB2	H	0	0	–	0	0	–
	BB4	H	0	0	–	0	0	–
	BB5	H	0	0	–	0	0	–
	BB6	H	0	0	–	0	0	–
	BB7	C	0	0	–	0	0	–

[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 Chapter 2, Description of Proposed Action and Alternatives.
[3]Where a range of values is given, the maximum values are compared.
[4]Change due to updated units for this bin between Draft and Final. Draft reported in count (C) and Final reported in hours (H).
[5]Formerly ASW2 (H) in Phase II.

Table 2: Change in Annual Sonar and Other Transducers Usage during Testing Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS

For Annual Testing Activities								
Source Class Category	*Bin*	*Unit*[1]	*Annual Usage*[2]					
			Alternative 1			*Alternative 2*		
			Draft	*Final*	*Change*	*Draft*	*Final*	*Change*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	H	1,308	1,308	–	1,308	1,308	–
	LF4	H	971	971	–	971	971	–
		C	20	20	–	20	20	–
	LF5	H	1,752	1,752	–	1,752	1,752	–
	LF6	H	40	40	–	40	40	–
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	H	3,337	3,337	–	3,337	3,337	–
	MF1K	H	152	152	–	152	152	–
	MF3	H	12,291	1,257	-11,034[4]	12,291	1,257	-11,034[4]
	MF4	H	370–803	370–803	–	803	761-803	–[3]
	MF5	C	5,070–6,182	5,070–6,182	–	6,382	6,382	–
	MF6	C	1,256–1,341	1,256–1,341	–	1,391	1,391	–
	MF8	H	348	348	–	348	348	–
	MF9	H	7,394–7,561	7,395–7,562		7,561	7,561	–
	MF10	H	5,690	5,690	–	5,690	5,690	–
	MF11	H	1,424	1,424	–	1,424	1,424	–
	MF12	H	1,388	1,388	–	1,388	1,388	–
	MF14	H	1,440	1,440	–	1,440	1,440	–

Table 2: Change in Annual Sonar and Other Transducers Usage during Testing Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS (continued)

For Annual Testing Activities								
Source Class Category	*Bin*	*Unit[1]*	*Annual Usage[2]*					
			Alternative 1			*Alternative 2*		
			Draft	*Final*	*Change*	*Draft*	*Final*	*Change*
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	H	397	397	–	397	397	–
	HF3	H	31	31	–	31	31	–
	HF4	H	30,772–30,828	30,772–30,828	–	30,828	30,828	–
	HF5	H	1,864–2,056	1,864–2,056	–	2,056	2,056	–
		C	40	40	–	40	40	–
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF6	H	2,193	2,193	–	2,193	2,193	–
	HF7	H	1,224	1,224	–	1,224	1,224	–
	HF8	H	2,084	2,084	–	2,084	2,084	–
Very High Frequency Sonars (VHF): Non-tactical sources that produce signals between 100 and 200 kHz	VHF1	H	12	12	–	12	12	–
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	H	820	820	–	820	820	–
	ASW2	C	4,756–5,606	4,756–5,606	–	6,106	6,106	–
	ASW3	H	2,941–3,325	2,941–3,325	–	3,325	3,325	–
	ASW4	C	3,493	3,493	–	3,493	3,493	–
	ASW5[5]	H	608–628	608–628	–	708	708	–
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	C	806–980	806–980	–	980	980	–
	TORP2	C	344–408	344–408	–	408	408	–
	TORP3	C	0	100	+100	0	100	+100

Table 2: Change in Annual Sonar and Other Transducers Usage during Testing Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS (continued)

For Annual Testing Activities								
Source Class Category	*Bin*	*Unit*[1]	*Annual Usage*[2]					
			Alternative 1			*Alternative 2*		
			Draft	*Final*	*Change*	*Draft*	*Final*	*Change*
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	H	1,224	1,224	–	1,224	1,224	–
Acoustic Modems (M): Systems used to transmit data through the water	M3	H	634	634	–	634	634	–
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged *swimmers*	SD1–SD2	H	176	176	–	176	176	–
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	H	960	960	–	960	960	–
	SAS2	H	3,512	3,512	–	3,512	3,512	–
	SAS3	H	960	960	–	960	960	–
	SAS4	H	960	960	–	960	960	–
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB1	H	960	960	–	960	960	–
	BB2	H	960	960	–	960	960	–
	BB4	H	876–3,252	876–3,252	–	3,252	3,252	–
	BB5	H	672	672	–	672	672	–
	BB6	H	672	672	–	672	672	–
	BB7	C	120	120	–	120	120	–

[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 Chapter 2, Description of Proposed Action and Alternatives.
[4]Change due to updated units for this bin between Draft and Final. Draft reported in count (C) and Final reported in hours (H).
[5]Formerly ASW2 (H) in Phase II.

Table 3: Change in Annual Explosive Usage during Training Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS

For Annual Training Activities								
Bin	Net Explosive Weight[1] (lb.)	Example Explosive Source	Annual[2] Usage					
			Alternative 1			Alternative 2		
			Draft	Final	Change	Draft	Final	Change
E1	0.1–0.25	Medium-caliber projectile	10,340	7,700	-2,640	10,340	7,700	-2,640
E2	> 0.25–0.5	Medium-caliber projectile	210–214	210–214	–	214	214	–
E3	> 0.5–2.5	Large-caliber projectile	3,286	4,592	+1,306	3,286	4,592	+1,306
E4	> 2.5–5	Mine neutralization charge	127–133	127–133	–	133	133	–
E5	> 5–10	5 in. projectile	4,140	1,436	-2,704	4,140	1,436	-2,704
E6	> 10–20	Hellfire missile	602	602	–	602	602	–
E7	> 20–60	Demo block/ shaped charge	4	4	–	4	4	–
E8	> 60–100	Lightweight torpedo	48	22	-26	48	22	-26
E9	> 100–250	500 lb. bomb	66	66	–	66	66	–
E10	> 250–500	Harpoon missile	90	90	–	90	90	–
E11	> 500–650	650 lb. mine	1	1	–	1	1	–
E12	> 650–1,000	2,000 lb. bomb	18	18	–	18	18	–
E14[3]	> 1,741–3,625	Line charge	0	0	–	0	0	–
E16[4]	> 7,250–14,500	Littoral Combat Ship full ship shock trial	0	0	–	0	0	–
E17[4]	> 14,500–58,000	Aircraft carrier full ship shock trial	0	0	–	0	0	–

[1] Net Explosive Weight refers to the equivalent amount of trinitrotoluene (TNT) 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).

Table 4: Change in Annual Explosive Usage during Testing Activities Analyzed in this Final EIS/OEIS Compared to the Draft EIS/OEIS

For Annual Testing Activities								
Bin	*Net Explosive Weight[1] (lb.)*	*Example Explosive Source*	*Annual[2] Usage*					
			Alternative 1			*Alternative 2*		
			Draft	*Final*	*Change*	*Draft*	*Final*	*Change*
E1	0.1–0.25	Medium-caliber projectile	17,840–26,840	17,840–26,840	–	26,840	26,840	–
E2	> 0.25–0.5	Medium-caliber projectile	0	0	–	0	0	–
E3	> 0.5–2.5	Large-caliber projectile	2,814–3,182	3,054–3,422	+240[5]	3,182	3,422	+240
E4	> 2.5–5	Mine neutralization charge	746–800	746–800	–	810	810	–
E5	> 5–10	5 in. projectile	1,325	1,325	–	1,325	1,325	–
E6	> 10–20	Hellfire missile	28–48	28–48	–	48	48	–
E7	> 20–60	Demo block/ shaped charge	0	0	–	0	0	–
E8	> 60–100	Lightweight torpedo	33	33	–	33	33	–
E9	> 100–250	500 lb. bomb	4	4	–	4	4	–
E10	> 250–500	Harpoon missile	68–98	68–98	–	98	98	–
E11	> 500–650	650 lb. mine	10	10	–	20	20	–
E12	> 650–1,000	2,000 lb. bomb	0	0	–	0	0	–
E14[3]	> 1,741–3,625	Line charge	4	4	–	4	4	–
E16[4]	> 7,250–14,500	Littoral Combat Ship full ship shock trial	0–12	0–12	–	0–12	0–12	–
E17[4]	> 14,500–58,000	Aircraft carrier full ship shock trial	0–4	0–4	–	0–4	0–4	–

[1] Net Explosive Weight refers to the equivalent amount of trinitrotoluene (TNT) 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).

[5] Where a range of values is given, the maximum values are compared.

- Section 3.1 (Air Quality):
  Changes were made to the General Conformity Rule Evaluation section clarifying total direct and indirect emissions and emissions from mobile sources as well as more information regarding attainment and National Ambient Air Quality Standards was added. The Record of Non-Applicability was signed by the Navy and included in Appendix C.

- Section 3.2 (Sediments and Water Quality):
  Changes were made to the description of sediment class sizes in the Affected Environment section to be consistent with a single, modern classification system. Adjustments to all figures were made to ensure the figures are consistent in labeling and nomenclature with other sections in the Final EIS/OEIS. The remaining changes were minor editorial changes to correct errors in grammar and spelling or to clarify the meaning of a statement or description.

- Section 3.3 (Vegetation):
  Adjustments to all figures were made to ensure the figures are consistent in labeling and nomenclature with other sections in the Final EIS/OEIS. Impacts to bottom habitats were updated as appropriate. Additional description and analysis was provided for tidal emergent marsh vegetation and marine debris impacts. ESA conclusions for Johnson's seagrass were updated to "no effect." The remaining changes were minor editorial changes to correct errors in grammar and spelling or to clarify the meaning of a statement or description.

- Section 3.4 (Marine Invertebrates):
  The General Background section was updated to include information on the revised estimated number of marine invertebrate species, habitat use, movement and behavior, and threats. Descriptions of sound (particle acceleration) and sediment vibration perception capabilities were updated based on numerous recent studies, and analysis of acoustic impacts on invertebrates was updated accordingly. Descriptions of species listed under the ESA was revised to reflect listing decisions on several coral species and the queen conch (*Lobatus gigas*), as well as changes to common and scientific names. Information on the occurrence of deep-water corals, mesophotic corals, and chemosynthetic communities was added or substantially revised. Overall analyses of impacts on invertebrates were revised based on recent scientific research and changes to the type and number of training and testing activities and expended materials, as described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.3 (Identifying Stressors for Analysis), and Appendices A (Navy Activity Descriptions), B (Activity Stressor Matrices), and F (Military Expended Materials and Direct Strike Impact Analyses). Discussion of Essential Fish Habitat was removed from the invertebrates section, and discussion of hard bottom habitat was moved to the Habitats section (Section 3.0.5).

- Section 3.5 (Marine Habitats):
  Changes in quantities of explosives on or near the bottom and military expended materials were adjusted based on changes made to Chapter 2 (Description of Proposed Action and Alternatives) and tables in Section 3.0.5.3 (Identification of Stressors for Analysis). The analyses of impacts on marine habitats as a result of these changes were modified accordingly. Impacts of explosives and military expended materials were assessed based on three types of analyses: (1) a conservative scenario assuming all the impacts occur on a single habitat type in an affected area (in a one year-increment), (2) a more realistic situation in which the impacts are spread proportionally among the habitat types in an affected area (e.g., if hard bottom represents 10 percent of the total habitat within a particular testing or training area or range complex, then 10 percent of the total impact is assumed to occur on hard bottom), and (3) in an increment of 5 years.

  In addition, abiotic habitat types were further differentiated in the Navy's Aquatic Habitat Mapping Database as "soft", "intermediate", and "hard" substrate. Soft substrate areas are dominated by mud (including clay and silt) or sand. Hard substrate areas are dominated by rocks or consolidated bedrock. Intermediate substrate areas are dominated by unconsolidated material larger than sand but smaller than rocks (e.g., gravel). Additionally, the habitats database was updated to include recently published data sources including both mapped polygon and point data.

- Section 3.6 (Fishes):
  ESA status of various species were updated based on National Marine Fisheries Service (NMFS) Final Rules that were published after the Draft EIS/OEIS. Also, ESA analysis and conclusions were updated to correspond with the results of recent ESA consultations. After the release of the Draft EIS/OEIS, NMFS designated critical habitat for the Atlantic sturgeon. That information has been added to this Final EIS/OEIS.

- Section 3.7 (Marine Mammals):
  Marine mammal species listing status, abundance estimates, and general threats discussions were updated based on the most recent stock assessment reports and new literature. The analyses of impacts on marine mammals as a result of changes to annual levels of certain activities, as detailed in Chapter 2 (Description of Proposed Action and Alternatives) and updated information on entanglement stressors described in Section 3.0.5.3 (Identification of Stressors for Analysis) were modified accordingly. The acoustic analysis was revised to more accurately quantify the expected acoustic effects on marine mammals, taking into consideration animal avoidance or movement and procedural mitigation measures. The ship strike probability analysis was revised to address a request from the NMFS that was raised during ESA consultation. Updates to mitigation measures were also included as a result of completing consultations under the Marine Mammal Protection Act (MMPA) and ESA.

- Section 3.8 (Reptiles):
  The analyses of impacts to sea turtles and other marine reptiles as a result of changes to annual levels of certain activities, as detailed in Chapter 2 (Description of Proposed Action and Alternatives) and tables in Section 3.0.3.3 (Identifying Stressors for Analysis) were modified accordingly. Additional information and analyses were added to the Final EIS/OEIS regarding training and testing activities in inshore locations. Specifically, more detailed analyses regarding terrapins and crocodilians were added to this section.

- Section 3.9 (Birds and Bats):
  Adjustments to all figures were made to ensure the figures are consistent in labeling and nomenclature with other sections in the Final EIS/OEIS. Background information on white-nosed syndrome in northeastern states, closer to the Study Area, was added. ESA conclusions were updated to reflect the Biological Assessment and section 7 consultation package. Additional hearing references were added. Potential for helicopter noise exposure was clarified, and additional information about animal flight altitude was added for assessing acoustic exposures. The remaining changes were minor editorial changes to correct errors in grammar and spelling or to clarify the meaning of a statement or description.

- Section 3.10 (Cultural Resources):
  Minor corrections and edits were made, including correcting cross-references to tables in Section 3.0.

- Section 3.11 (Socioeconomic Resources):
  Changes were made to the descriptions of offshore wind and hydrokinetic energy development projects to update the status of the projects. Adjustments to all figures were made to ensure the figures are consistent in labeling and nomenclature with other sections in the Final EIS/OEIS. Updates to data on recreational fisheries, commercial fisheries, commercial transportation and shipping, and tourism were made to incorporate the most recent available annual data, such as the amount and value of commercial landings, the volume of goods processed at commercial ports, and the economic contribution of tourism the states' economies.

- Section 3.12 (Public Health and Safety):
  Updates and edits were made with regard to the latest regulations and standard operating procedures that benefit public health and safety.

- Chapter 4 (Cumulative Impacts):
  Non-substantive changes were made throughout Chapter 4 (Cumulative Impacts) to maintain alignment and consistency with updates to Chapters 1-3 (Purpose and Need, Description of Proposed Action and Alternatives, and Affected Environment and

Environmental Consequences), to reflect the availability of updated data, and to correct minor editorial issues.

Additionally, the past, present, and reasonably foreseeable projects and industry information described in Table 4.2-1 was updated where new information was available, and this new information was incorporated into the cumulative analysis for each resource as warranted. Revisions to military projects in Table 4.2-1 included the update of Eglin Air Force Base Gulf Test and Training Range activities; the addition of the Demolition/ Replacement of Pier 32/ Demolition of Pier 10 at Naval Submarine Base New London, Connecticut; the addition of AFTT Phase II discussion of past and ongoing activities; and a revised discussion of Surveillance Towed Array Sensor System Low Frequency Active Sonar systems to clarify that this activity has never been operated within the project area. Updates to outer continental shelf commercial industries information included discussion of 2017 Executive Order Implementing an America-First Offshore Energy Strategy and May 2017 Department of the Interior Secretary Order 3350 Implementing the America-First Offshore Energy Strategy and addition of marine hydrokinetic power generation as a potential future action. Ocean pollution and ecosystem alteration trends were removed from Table 4.2-1 to create Table 4.2-2 in the Final EIS/OEIS that focuses on the known impacts of each specific stressor.

Minor changes were made with respect to the cumulative effects analysis of specific resources. Discussion of invertebrates, particularly the impact of climate change on corals, was expanded. Additional stressors of power plant entrainment and disease, parasites, and algae were added to marine mammals discussion, and a limited discussion of diamondback terrapin was added to the reptiles discussion. All other changes to the cumulative analysis of specific resources incorporate relevant changes that were made to corresponding resource analyses in Chapter 3 (see bullet list, above).

- Chapter 5 (Mitigation):
  Based on its ongoing analysis of the best available science and potential mitigation measures, the Navy determined it would be practical to implement additional mitigation measures to enhance protection of marine mammals (including Bryde's whales and ESA-listed North Atlantic right whales) to the maximum extent practicable. The new mitigation measures are detailed in the Final EIS/OEIS and include: (1) enlarging the Northeast North Atlantic Right Whale Mitigation Area to cover the full extent of the northeast North Atlantic right whale critical habitat, (2) expanding the Gulf of Mexico Planning Awareness Area to cover the full extent of the Bryde's whale small and resident population area that was expanded during the 2016 NMFS status review, (3) developing a new Bryde's Whale Mitigation Area to restrict all explosives except for mine warfare activities in the expanded Bryde's whale small and resident population area, (4) implementing special reporting procedures for the use of active sonar and in-water explosives within the newly developed Southeast North Atlantic Right Whale Critical Habitat Special Reporting Area and Bryde's

Whale Mitigation Area, and newly expanded Northeast North Atlantic Right Whale Mitigation Area and Southeast North Atlantic Right Whale Mitigation Area, (5) adding a requirement for Navy units conducting training or testing activities in the Jacksonville Operating Area to use Early Warning System North Atlantic right whale sightings data as they plan specific details of events and to assist visual observation of applicable mitigation zones to minimize potential interactions with North Atlantic right whales to the maximum extent practicable, (6) adding seafloor resource mitigation areas for submerged aquatic vegetation, (7) adding a requirement to confer with NMFS if the Navy needs to conduct additional major training exercises in the Gulf of Maine Planning Awareness Mitigation Area or Gulf of Mexico Planning Awareness Mitigation Area, (8) adding a requirement to transmit special notification messages to applicable naval units with information from the North Atlantic right whale Dynamic Management Areas, (9) adding a requirement to survey for marine mammals and ESA-listed species after the completion of explosive activities in the vicinity of where detonations occurred (when practical), (10) requiring additional platforms already participating in explosive activities to support observing for applicable biological resources before, during, and after the activity, (11) adding reporting requirements, such as a requirement to report sea turtle vessel strikes and a monitoring initiative to evaluate the extent to which military expended materials may have impacted ESA-listed corals and designated coral critical habitat in or near the Key West Range Complex, (12) adding a requirement for vessels to operate within specific water depths within the Key West Range Complex to avoid bottom scouring and prop dredging, and (13) adding a mitigation measure to 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 within 3.2 NM of an estuarine inlet and within 1.6 NM of the shoreline in the Navy Cherry Point Range Complex from March through September to the maximum extent practicable to avoid or reduce potential impacts on sea turtles near nesting beaches during the nesting season and on sandbar sharks in Habitat Areas of Particular Concern.

- Chapter 6 (Regulatory Considerations):
  The summary paragraphs for each National Marine Sanctuary were updated to more clearly state whether or not section 304(d) consultation was required for the Sanctuary and to include the findings from the Sanctuary Resource Statements. Updates were made to the status of the Coastal Zone Management Act Compliance process as well as the Magnuson-Stevens Fishery and Conservation Management Act subsection. To address public comments received, new Marine Protected Areas that border inland waters included in the Proposed Action were added to Table 6.1-2, and a new figure was added to display the Marine Protected Areas around Puerto Rico and the Caribbean.

- Chapter 7 (List of Preparers):
  Changes were made to update the List of Preparers based on changes in personnel working on the project.

- Chapter 8 (Public Involvement):
  Information regarding the public participation process, related to the release of the Draft EIS/OEIS, public meetings held, and the public comments received on the Draft EIS/OEIS comments were added.

- Appendix A (Navy Activity Descriptions):
  Changes were made to reflect modifications made to Chapter 2 (Description of Proposed Action and Alternatives) and to correct errors.

- Appendix B (Activity Stressor Matrices):
  Changes were made to reflect corrections made to Chapter 2 (Description of Proposed Action and Alternatives), Appendix A (Navy Activity Descriptions), and to correct errors.

- Appendix C (Air Quality Emission Calculations and Record of Non-Applicability):
  The example emissions calculations and Record of Non-Applicability were modified based on changes in numbers of annual events in Chapter 2 (Description of Proposed Action and Alternatives).

- Appendix D (Acoustic and Explosive Impacts):
  No changes have been made since the release of the Draft EIS/OEIS.

- Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities):
  Changes made to the exposure numbers reflected changes made to the sonar hours and counts, explosives, and activity numbers in Chapter 2 (Description of Proposed Action and Alternatives).

- Appendix F (Military Expended Material and Direct Strike Impact Analysis):
  Changes were made to the military expended materials tables and the benthic substrate impact tables to reflect modifications made to activity numbers in Chapter 2 (Description of Proposed Action and Alternatives) and to correct minor errors.

- Appendix G (Federal Register Notices):
  Additional Federal Register Notices since the public release of the Draft EIS/OEIS were added.

- Appendix H (Public Comment Responses):
  This Appendix was added since the release of the Draft EIS/OEIS and includes an explanation of the public comment process for the Draft EIS/OEIS, list of agencies and organizations that provided comments, and a table containing the comments received and the Navy's responses.

- Appendix I (Geographic Information System Data Sources):
  Geographic Information System data features and source information was updated.

- Appendix J (Agency Correspondence):
  Agency correspondence received since the public release of the Draft EIS/OEIS is included.

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

TABLE OF CONTENTS

List of Figures

List of Tables

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to assess the potential environmental impacts associated with two categories of military readiness activities: training and testing. Collectively, the at-sea areas in this EIS/OEIS are referred to as the Atlantic Fleet Training and Testing (AFTT) Study Area (Study Area) (Figure ES-1). The Navy also prepared this EIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114.

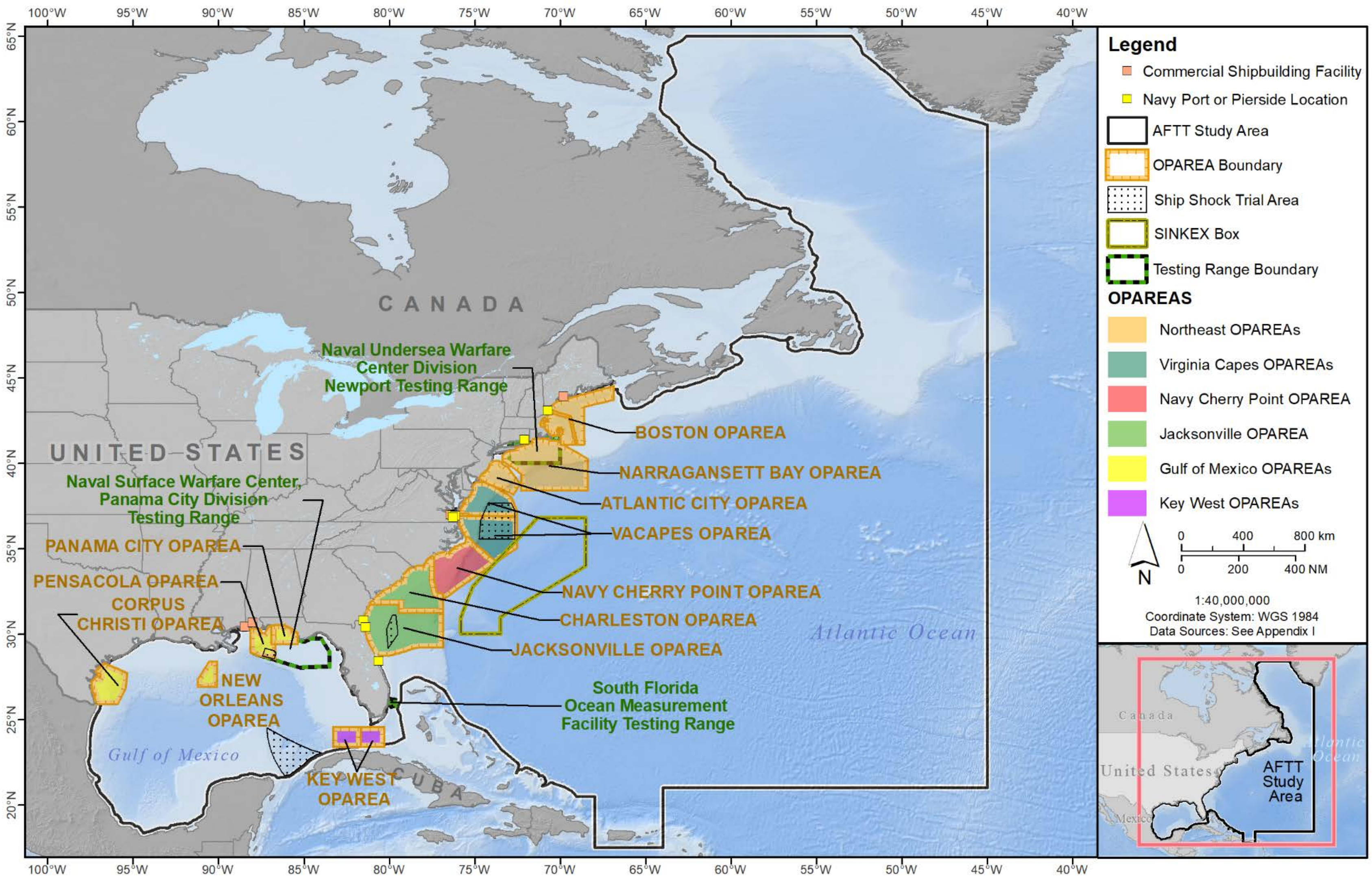
Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten the national security of the United States. United States national security, prosperity, and vital interests are increasingly tied to other nations because of the close relationships between the United States and other national economies. The Navy carries out training and testing activities to be able to protect the United States against its enemies, as well as to protect and defend the rights of the United States and its allies to move freely on the oceans. Training and testing activities that prepare the Navy to fulfill its mission to protect and defend the United States and its allies potentially impact the environment. These activities may trigger legal requirements identified in many U.S. federal environmental laws, regulations, and executive orders.

ES.2 PURPOSE AND NEED

The Navy and National Marine Fisheries Service (NMFS) (as a cooperating agency) have coordinated from the outset and developed this document to meet each agency's distinct NEPA obligations and support the decision making of both agencies. The purpose of the Proposed Action is to ensure that the Navy meets its mission under Title 10 United States Code Section 5062, which is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area. NMFS's purpose is to evaluate the Navy's proposed action pursuant to NMFS's authority under the Marine Mammal Protection Act (MMPA), and to make a determination whether to issue incidental take regulations and Letters of Authorization, including any conditions needed to meet the statutory mandates of the MMPA.

ES.3 SCOPE AND CONTENT OF THE ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

In this EIS/OEIS, the Navy assessed military readiness activities that could potentially impact human and natural resources, especially marine mammals, sea turtles, and other marine resources. The range of alternatives includes a No Action Alternative and other reasonable courses of action. Direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts were also analyzed. Data sets used for analysis were considered across the full spectrum of Navy training and testing for the foreseeable future. For the purposes of analysis and presentation within this EIS/OEIS, data was organized and evaluated in 1-year and 5-year increments. Based upon current knowledge and the proposed training and testing, the Navy does not reasonably foresee a change to the Navy's direct and indirect impact conclusions across other time frames (ex., 2, 7, 10 years). The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS.



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

Figure ES-1: Atlantic Fleet Training and Testing Study Area

The NMFS is a cooperating agency pursuant to 40 Code of Federal Regulations (CFR) section 1501.6 because of its expertise and regulatory authority over certain marine resources. Additionally, NMFS plans to use this document as its NEPA documentation for the rule making process under the MMPA.

In accordance with the Council on Environmental Quality Regulations, 40 CFR section 1505.2, the Navy will issue a Record of Decision. The decision will be based on factors analyzed in this EIS/OEIS, including military training and testing objectives, best available science and modeling data, potential environmental impacts, and public interest.

ES.3.1 National Environmental Policy Act

Federal agencies are required under NEPA to examine the environmental impacts of their proposed actions within the United States and its territories. An EIS is a detailed public document that provides an assessment of the potential effects that a major Federal action might have on the human environment, which includes the natural environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and Executive Orders. Presidential Proclamation 5928, issued December 27, 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nautical miles (NM); however, the proclamation expressly provides that it does not extend or otherwise alter existing Federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 NM under NEPA (an EIS).

ES.3.2 Executive Order 12114

This OEIS has been prepared in accordance with Executive Order 12114 (44 Federal Register 1957) and Navy implementing regulations in 32 CFR part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial limits (more than 12 NM from the coast) and Antarctica but do not include contiguous zones and fisheries zones of foreign nations (32 CFR section 187.3). The EIS and OEIS have been combined into one document, as permitted under NEPA and Executive Order 12114, to reduce duplication.

ES.3.3 Marine Mammal Protection Act

The MMPA of 1972 (16 US Code [U.S.C.] section 1361 et seq.) established, with limited exceptions, a moratorium on the “taking” of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates “takes” of marine mammals on the high seas by vessels or persons subject to U.S. jurisdiction. The term “take,” as defined in section 3 [16 U.S.C. section 1362(13)] of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The MMPA directs the Secretary of Commerce (as delegated to NMFS) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and on the availability of the species or stock for subsistence uses (where relevant), and requirements pertaining to the monitoring, and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment and removed the "small numbers" provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government consistent with section 104(c)(3) (16 U.S.C. section 1374 [c][3]). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (Public Law 107-314). A "military readiness activity" is defined as "all training and operations of the Armed Forces that relate to combat" and "the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." Since the Proposed Action involves conducting military readiness activities, the relevant definition of harassment is any act that:

- injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment") or
- disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 U.S.C. section 1362(18)(B)(i) and (ii)].

ES.3.4 ENDANGERED SPECIES ACT

The Endangered Species Act (ESA of 1973 (16 U.S.C. section 1531 et seq.) provides for the conservation of endangered and threatened species, and of the ecosystems on which they depend. The Act defines "endangered" species as a species in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. The U.S. Fish and Wildlife Service (USFWS) and NMFS jointly administer the ESA and are responsible for listing species (as threatened or endangered) and for designating critical habitat for listed species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a listed species, that agency is required to consult with the Service (NMFS or USFWS) that has jurisdiction over the species in question [50 CFR section 402.14(a)]. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be a prohibited taking under the act provided that such taking complies with the terms and conditions of an Incidental Take Statement.

ES.3.5 ADDITIONAL ENVIRONMENTAL REQUIREMENTS CONSIDERED

The Navy must comply with all applicable federal environmental laws, regulations, and Executive Orders, including, but not limited to, those listed below. Further information on Navy compliance with these and other environmental laws, regulations, and Executive Orders can be found in Chapter 1 (Purpose and Need), Chapter 3 (Affected Environment and Environmental Consequences) and Chapter 6 (Regulatory Considerations).

- Abandoned Shipwreck Act

- Antiquities Act
- Clean Air Act
- Clean Water Act
- Coastal Zone Management Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- National Marine Sanctuaries Act
- Rivers and Harbors Act
- Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*
- Executive Order 12962, *Recreational Fisheries*
- Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*
- Executive Order 13089, *Coral Reef Protection*
- Executive Order 13158, *Marine Protected Areas*
- Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*
- Executive Order 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

ES.4 PROPOSED ACTION AND ALTERNATIVES

The U.S. Navy proposes to conduct military readiness training activities (hereinafter referred to as "training") and research, development, testing, and evaluation (hereinafter referred to as "testing") activities in the AFTT Study Area, as represented in (Figure ES-1)**.** These military readiness activities include the use of active sonar and explosives within the in-water areas of the western Atlantic Ocean along the eastern coast of North America, in portions of the Caribbean Sea and the Gulf of Mexico, at select Navy pierside locations, within port transit channels, near select civilian ports, and in bays, harbors, and inshore waterways (e.g., lower Chesapeake Bay). These military readiness activities are generally consistent with those analyzed in the AFTT EIS/OEIS completed in November 2013 and are representative of training and testing that the Navy has been conducting in the AFTT Study Area for decades.

The Navy's entire suite of mitigation measures was developed in coordination with NMFS. The Action Alternatives and mitigation measures meet both the Navy's and NMFS's purpose and need. The Navy will implement mitigation to avoid or reduce potential impacts of training and testing activities on environmental and cultural resources under both action alternatives (Alternative 1 [Preferred Alternative] and Alternative 2).

ES.4.1 NO ACTION ALTERNATIVE

Under the No Action Alternative, the Proposed Action would not take place (i.e., the Navy would not conduct proposed training and testing activities in the AFTT Study Area). For NMFS, denial of an application for an incidental take authorization constitutes the NMFS No Action Alternative, which is consistent with NMFS' statutory obligation under the MMPA to grant or deny requests for take incidental to specified activities. The resulting environmental effects from taking no action will be compared with the effects of the Proposed Action.

ES.4.2 Alternative 1

Alternative 1 is the Preferred Alternative.

ES.4.2.1 Training

Under this alternative, 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 subject to previous analysis that are currently ongoing and have historically occurred in the Study Area. These activities account for force structure (organization of ships, weapons, and personnel) 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 and locations of all proposed training activities are provided in Table 2.6-1, in Section 2.6.1 (Proposed Training Activities).

Alternative 1 reflects a representative year of training to account for the natural fluctuation of training cycles and deployment schedules that generally limit the maximum level of training from occurring year after year in any five-year period. Using a representative level of activity rather than a maximum tempo of training activity in every year has reduced the amount of hull-mounted mid-frequency active sonar estimated to be necessary to meet training requirements, as discussed below. Both unit-level training and major training exercises are adjusted to meet this representative year.

Under Alternative 1, the Navy assumes that some unit-level training would be conducted using synthetic means (e.g., simulators). Additionally, this alternative assumes that some unit-level active sonar training will be completed through other training exercises by using a representative level of training activity rather than a maximum level of training activity in every year.

The Optimized Fleet Response Plan (which outlines the training activities required to achieve a state of Naval readiness) and various training plans identify the number and duration of training cycles that could occur over a five-year period. Alternative 1 considers 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. Similar to unit-level training, this alternative does not analyze a maximum number of carrier strike group Composite Training Unit Exercises (one type of major exercise) every year, but instead assumes a maximum number of exercises would occur during two years of any five-year period. As a result, Alternative 1 will analyze a maximum of three Composite Training Unit Exercises in any given year and not more than 12 over any five-year period. This alternative does not provide for the conduct of a contingency Composite Training Unit Exercise in the Gulf of Mexico and, hence, incorporates a degree of risk that the Navy will not have sufficient capacity to support the full spectrum of training potentially necessary to respond to a future national emergency crisis.

ES.4.2.2 Testing

Alternative 1 entails a level of testing activities to be conducted into the reasonably foreseeable future, with adjustments that account for changes in the types and tempo (increase or decrease) of testing activities, as necessary, to meet current and future military readiness requirements. This alternative includes the testing of new platforms, systems, and related equipment that will be introduced after November 2018. The majority of types of testing activities that would be conducted under this alternative are the same as or similar as those conducted currently or in the past. This alternative includes the testing of some new systems using new technologies and takes into account inherent uncertainties in this type of testing.

Under Alternative 1, the Navy proposes an annual level of testing that reflects the fluctuations in testing programs by recognizing that the maximum level of testing will not be conducted each year. This alternative contains a more realistic annual representation of activities, but includes years of a higher maximum amount of testing to account for these fluctuations. This alternative would not include the contingency for augmenting some weapon system tests, which would increase levels of annual testing of anti-submarine warfare and mine warfare systems, and presumes a typical level of readiness requirements. All proposed testing activities are listed in Table 2.6-2 through Table 2.6-4, in Section 2.6.2 (Testing).

ES.4.3 ALTERNATIVE 2

ES.4.3.1 TRAINING

As under Alternative 1, Alternative 2 includes new and ongoing activities. Under Alternative 2, training activities are based on requirements established by the Optimized Fleet Response Plan. Under this alternative, the Navy would be enabled to meet the highest levels of required military readiness by conducting the majority of its training live at sea, and by meeting unit level training requirements using dedicated, discrete training events, instead of combining them with other training activities as described in alternative 1. The numbers and locations of all proposed training activities are provided in Table 2.6 1, in Section 2.6.1 (Proposed Training Activities).

Alternative 2 reflects the maximum number of training activities that could occur within a given year, and assumes that the maximum level of activity would occur every year over any 5-year period. This allows for the greatest capacity for the Navy to maintain readiness when considering potential changes in the national security environment, fluctuations in training and deployment schedules, and potential in-theater demands. Both unit-level training and major training exercises are assumed to occur at a maximum level every year.

Additionally, this alternative will analyze three Composite Training Unit Exercises each year along with a contingency Composite Training Unit Exercise in the Gulf of Mexico each year, for a total number of Composite Training Unit Exercises to 20, including the Gulf of Mexico contingency Composite Training Unit Exercise, over any five-year period.

ES.4.3.2 TESTING

Alternative 2 entails a level of testing activities to be conducted into the reasonably foreseeable future, and includes the testing of new platforms, systems, and related equipment that will be introduced after November 2018. The majority of testing activities that would be conducted under this alternative are the same as or similar to those conducted currently or in the past.

Alternative 2 would include the testing of some new systems using new technologies, taking into account the potential for delayed or accelerated testing schedules, variations in funding availability, and innovation in technology development. To account for these inherent uncertainties in testing, this alternative assumes that the maximum annual testing efforts predicted for each individual system or program could occur concurrently in any given year. This alternative also includes the contingency for augmenting some weapon systems tests in response to potential increased world conflicts and changing Navy leadership priorities as the result of a direct challenge from a naval opponent that possesses near-peer capabilities. Therefore, this alternative includes the provision for higher levels of annual testing of certain anti-submarine warfare and mine warfare systems to support expedited delivery of these systems to the fleet. All proposed testing activities are listed in Table 2.6-2 through Table 2.6-4, in Section 2.6.2 (Proposed Testing Activities).

ES.5 Summary of Environmental Effects

Environmental effects which might result from implementing the Navy's Proposed Action or alternatives have been analyzed in this EIS/OEIS. Resource areas analyzed include air quality, sediments and water quality, vegetation, invertebrates, habitats, fishes, marine mammals, reptiles, birds and bats, cultural resources, socioeconomics, and public health and safety. Table ES 5-1 provides a comparison of the potential environmental impacts of the No Action Alternative, Alternative 1 (Preferred Alternative), and Alternative 2.

This EIS/OEIS covers similar types of Navy training and testing activities in the same study area analyzed in the 2013 AFTT Final EIS/OEIS. The Navy has re-evaluated impacts from these ongoing activities in existing ranges and operating areas (OPAREAs) offshore of the eastern and gulf coasts. The Navy analyzed new or changing military readiness activities into the reasonably foreseeable future based on evolving operational requirements, including those associated with new platforms and systems not previously analyzed, and new inshore water training locations. Additionally, the Navy thoroughly reviewed and incorporated the best available science relevant to analyzing the environmental impacts of the proposed activities. Changes from the 2013 AFTT Final EIS/OEIS include the following:

ES.5.1 Sonar and Explosives

The Navy's refined analysis of anti-submarine warfare activities results in reduced levels of active sonar being analyzed. The new presentation of anti-submarine warfare activities more accurately reflects the variability in the number of certification related events (e.g., Composite Training Exercise) conducted per year due to varying deployment schedules and ship availabilities. This new analysis also better accounts for a portion of unit level surface ship tracking exercise requirements being met during coordinated/integrated anti-submarine warfare training and major training exercises, or through synthetic training. These refinements to the analysis result in fewer hours of acoustic sources, such as hull-mounted mid-frequency active acoustic systems, when estimating marine mammal exposures from training events.

This EIS/OEIS supports the Navy's increased focus on live training to meet evolving surface warfare challenges. This results in a proposed increase in levels of Air-to-Surface Warfare activities and an increased reliance on non-explosive and explosive munitions usage of rockets, missiles, and bombs.

The number of Sinking Exercises proposed by the Navy has been reduced to reflect expected availability of Sinking Exercise targets.

Increases in training for maritime security operations (e.g., drug interdiction, anti-piracy) are proposed to ensure Sailors are prepared to meet this important mission area.

The sonar bin list has been updated/refined to reflect new active sonar sources, such as high-frequency imaging sonars and broadband sound sources proposed for testing and experimentation. Similarly, specific existing bins were refined to better reflect testing realism in the analysis.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2

Resource Category	***Summary of Impacts***
Section 3.1-Air Quality	The Navy considered all potential stressors that air quality could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **<u>No Action Alternative:</u>** • Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. The No Action Alternative would not measurably improve air quality in the Study Area because of the discontinuous nature of the events that constitute the Proposed Action and the fact that most of the air emissions that are generated occur at sea over a wide geographic area. The elimination of the air emissions associated with activities in the lower Chesapeake Bay and its tributaries may be beneficial to local air quality in this region because it is the area of highest activity in state waters. It should be noted that the air quality in this area already surpasses the National Ambient Air Quality Standards. **<u>Alternative 1 (Preferred Alternative):</u>** • <u>Criteria Pollutants</u>: The emission of criteria pollutants resulting from training and testing activities in the Study Area would not cause a violation or contribute to an ongoing violation of the National Ambient Air Quality Standards. **<u>Alternative 2:</u>** • <u>Criteria Pollutants</u>: The emission of criteria pollutants resulting from training and testing activities associated with Alternative 2 would increase slightly over emissions from Alternative 1; however, they would not cause a violation or contribute to an ongoing violation of the National Ambient Air Quality Standards.
Section 3.2-Sediments and Water Quality	The Navy considered all potential stressors that sediments and water quality could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **<u>No Action Alternative:</u>** • Under the No Action Alternative there would be no adverse impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of explosives and explosives byproducts, metals, chemicals other than explosives, and other military expended materials would decrease the amounts of these materials in marine waters and sediments. The effect, however, would likely not be measureable due to the slow, sometimes decades-long corrosion of metals on the seafloor. **<u>Alternative 1 (Preferred Alternative):</u>** • <u>Explosives and explosives byproducts:</u> Impacts from explosives and explosives byproducts would be short term and local. Impacts from unconsumed explosives and constituent chemical compounds would be minimal and limited to the area adjacent to the munition. Explosives and constituent compounds could persist in the environment depending on the integrity of the undetonated munitions casing and the physical conditions on the seafloor where the munition resides. Chemical and physical changes to sediments and water quality, as measured by the concentrations of contaminants or other anthropogenic compounds, may be detectable and would be below applicable regulatory standards for determining effects on biological resources and habitats.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.2-Sediments and Water Quality (continued)	• <u>Chemicals other than explosives:</u> Impacts from other chemicals not associated with explosives would be both short term and long term depending on the chemical and the physical conditions on the seafloor where the source of the chemicals resides. Impacts would be minimal and localized to the immediate area surrounding the source of the chemical release. • <u>Metals:</u> Impacts from metals would be minimal, long-term, and dependent on the metal and the physical conditions on the seafloor where the metal object (e.g., non-explosive munition) resides. Impacts would be localized to the area adjacent to the metal object. Concentrations of metal contaminants near the expended material or munition may be measurable and are likely to be similar to the concentrations of metals in sediments from nearby reference locations. • <u>Other materials:</u> Impacts from other expended materials not associated with munitions would be both short term and long term depending on the material and the physical conditions (e.g., substrate, temperature, currents) on the seafloor where the material resides. Impacts would be localized to the immediate area surrounding the material. Chemical and physical changes to sediments and water quality, as measured by the concentrations of contaminants or other anthropogenic compounds near the expended material, are not likely to be detectable and would be similar to the concentrations of chemicals and material residue from nearby reference locations. **<u>Alternative 2:</u>** • <u>Explosives and explosives byproducts:</u> Impacts from explosives under Alternative 2 for training and testing activities would be identical (less than 1 percent difference in any location or overall) to those of Alternative 1. • <u>Chemicals other than explosives</u>: Impacts from other chemicals not associated with explosives under Alternative 2 would increase slightly compared to those of Alternative 1 because of a small increase in expended materials, but the difference in impacts would be undetectable. • <u>Metals:</u> Impacts from other chemicals not associated with explosives under Alternative 2 would increase slightly compared to those of Alternative 1 because of a small increase in expended materials, but the difference in impacts would be undetectable. • <u>Other military expended materials:</u> Impacts from other chemicals not associated with explosives under Alternative 2 would increase slightly compared to those of Alternative 1 because of a small increase in expended materials, but the difference in impacts would be undetectable.
Section 3.3-Vegetation	The Navy considered all potential stressors that vegetation could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **<u>No Action Alternative:</u>** • Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various stressors would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	*Summary of Impacts*
Section 3.3-Vegetation (continued)	**Alternative 1 (Preferred Alternative):** • Acoustics: There is no evidence that underwater acoustic stressors impact marine vegetation. Acoustic stressors, therefore, are not analyzed for vegetation. • Energy: Energy stressors are not applicable to vegetation because vegetation have a limited sensitivity to energy stressors and therefore will not be analyzed further in vegetation. • Explosives: Explosives could affect vegetation by destroying individual plants or damaging parts of plants; however, there would be no persistent or large-scale effects on the growth, survival, distribution or structure of vegetation due to relatively fast growth, resilience, and abundance of the most affected species (e.g., phytoplankton, seaweed). • Physical Disturbance and Strikes: Physical disturbance and strike could affect vegetation by destroying individual plants or damaging parts of plants; however, there would be no persistent or large-scale effects on the growth, survival, distribution or structure of vegetation due to relatively fast growth, resilience, and abundance of the most affected species (e.g., phytoplankton, seaweed). • Entanglement: Entanglement stressors are not applicable to vegetation due to the sedentary nature of vegetation and is not analyzed further in this section. • Ingestion: Ingestion stressors are not applicable because all vegetation analyzed uses photosynthesis vice ingestion to obtain necessary nutrients. Therefore, the ingestion stressor is not analyzed for vegetation. • Secondary Stressors: Project effects on secondary stressors such as sediment, water, or air quality would be minor, temporary, and localized and could have short-term, small-scale secondary effects on vegetation; however, there would be no persistent or large-scale effects on the growth, survival, distribution, or structure of vegetation due to relatively fast growth, resilience, and abundance of the most affected species (e.g., phytoplankton, seaweed). **Alternative 2:** • Explosives: Impacts from explosives under Alternative 2 for training and testing activities would be virtually identical (less than 1 percent difference in any location or overall) to those of Alternative 1. • Physical Disturbance and Strikes: Compared to Alternative 1, under Alternative 2, training and testing activities would be similarly distributed across ranges and facilities, but the number of activities would increase by a small percent. The net impact on vegetation is still expected to be nearly identical to that of Alternative 1. • Secondary Stressors: The difference in project effects on secondary stressors between Alternative 1 and 2 is inconsequential.
Section 3.4-Invertebrates	The Navy considered all potential stressors that invertebrates could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **No Action Alternative:** • Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various stressors (e.g., military expended materials other than munitions) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.4- Invertebrates (continued)	**<u>Alternative 1 (Preferred Alternative):</u>** • <u>Acoustics:</u> Invertebrates could be exposed to noise from the proposed training and testing activities. However, available information indicates that invertebrate sound detection is primarily limited to low-frequency (less than 1 kilohertz [kHz]) particle motion and water movement that diminishes rapidly with distance from a sound source. The expected impact of noise on invertebrates is correspondingly diminished and mostly limited to offshore surface layers of the water column where only zooplankton, squid, and jellyfish are prevalent mostly at night when training and testing occur less frequently. Invertebrate populations are typically lower offshore, where most training and testing occurs, than inshore due to the scarcity of habitat structure and comparatively lower nutrient levels. Exceptions occur at nearshore and inshore locations where occasional pierside sonar, air gun, or pile driving actions occur near relatively resilient soft bottom or artificial substrate communities. Because the number of individuals affected would be small relative to population numbers, population-level impacts are unlikely. • <u>Explosives:</u> Explosives produce pressure waves that can harm invertebrates in the vicinity of where they typically occur: mostly offshore surface waters where zooplankton, squid, and jellyfish are prevalent mostly at night when training and testing with explosives do not typically occur. Invertebrate populations are generally lower offshore than inshore due to the scarcity of habitat structure and comparatively lower nutrient levels. Exceptions occur where explosives are used on the bottom within nearshore or inshore waters on or near sensitive live hard bottom communities. Soft bottom communities are resilient to occasional disturbances. Due to the relatively small number of individuals affected, population-level impacts are unlikely. • <u>Energy:</u> The proposed activities would produce electromagnetic energy that briefly affects a very limited area of water, based on the relatively weak magnetic fields and mobile nature of the stressors. Whereas some invertebrate species can detect magnetic fields, the effect has only been documented at much higher field strength than what the proposed activities generate. High-energy lasers can damage invertebrates. However, the effects are limited to surface waters where relatively few invertebrates species occur (e.g., zooplankton, squid, jellyfish), mostly at night when actions do not typically occur, and only when the target is missed. Due to the relatively small number of individuals that may be affected, population-level impacts are unlikely. • <u>Physical Disturbance and Strikes:</u> Invertebrates could experience physical disturbance and strike impacts from vessels and in-water devices, military expended materials, seafloor devices, and pile driving. Most risk occurs offshore (where invertebrates are less abundant) and near the surface where relatively few invertebrates occur during the day when actions are typically occurring. The majority of expended materials are used in areas far from nearshore and inshore bottom areas where invertebrates are the most abundant. Exceptions occur for actions taking place within inshore and nearshore waters over primarily soft bottom communities, such as related to vessel transits, inshore and nearshore vessel training, nearshore explosive ordnance disposal training, operation of bottom-crawling seafloor devices, and pile driving. Invertebrate communities in affected soft bottom areas are naturally resilient to occasional disturbances. Accordingly, population-level impacts are unlikely.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.4-Invertebrates (continued)	• Entanglement: Invertebrates could be entangled by various expended materials (wires, cables, decelerators/parachutes, biodegradable polymer). Most entanglement risk occurs in offshore areas where invertebrates are relatively less abundant. The risk of entangling invertebrates is minimized by the typically linear nature of the expended structures (e.g., wires, cables), although decelerators/parachutes have mesh that could pose a risk to those invertebrates that are large and slow enough to be entangled (e.g., jellyfish). Deep-water coral could also be entangled by drifting decelerators/parachutes, but a co-occurrence is highly unlikely given the extremely sparse coverage of corals in the deep ocean. Accordingly, population-level impacts are unlikely. • Ingestion: Small expended materials and material fragments pose an ingestion risk to some invertebrates. However, most military expended materials are too large to be ingested, and many invertebrate species are unlikely to consume an item that does not visually or chemically resemble its natural food. Exceptions occur for materials fragmented by explosive charges or weathering, which could be ingested by filter- or deposit-feeding invertebrates. Ingestion of such materials would likely occur infrequently, and only invertebrates located very close to the fragmented materials would potentially be affected. Furthermore, the vast majority of human deposited ingestible materials in the ocean originate from non-military sources. Accordingly, population-level impacts are unlikely. • Secondary Stressors: Secondary impacts on invertebrates are possible via changes to habitats (sediment or water) and to prey availability due to explosives, explosives byproducts, unexploded munitions, metals, and toxic expended material components. Other than bottom-placed explosives, the impacts are mostly in offshore waters where invertebrates are less abundant. The impacts of occasional bottom-placed explosives are mostly limited to nearshore soft bottom habitats that recover quickly from disturbance. Following detonation, concentrations of explosive byproducts are rapidly diluted to levels that are not considered toxic to marine invertebrates. Furthermore, most explosive byproducts are common seawater constituents. Contamination leaching from unexploded munitions is likely inconsequential because the material has low solubility in seawater and is slowly delivered to the water column. Heavy metals and chemicals such as unspent propellants can reach harmful levels around stationary range targets but are not likely in open waters where proposed action targets are typically mobile or temporarily stationary. Accordingly, overall impacts of secondary stressors on widespread invertebrate populations are not likely. Impacts due to decreased availability of prey items (fish and other invertebrates) would likely be undetectable. **Alternative 2:** • Acoustics: Potential impacts to invertebrates would be similar to those discussed for training and testing activities under Alternative 1. The only difference in sonar and other transducer use between Alternatives 1 and 2 is that the number of sonar hours used would be greater under Alternative 2. Air guns and pile driving impacts would be the same under Alternative 2. Potential impacts resulting from vessel noise would be similar to those discussed for activities under Alternative 1. Vessel use in the Study Area would increase by a very small amount (about one percent). The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While the types of

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	*Summary of Impacts*
Section 3.4-Invertebrates (continued)	expected impacts to any individual invertebrate or group of invertebrates capable of detecting sounds produced during training and testing activities would remain the same, more animals could be affected. • Explosives: The locations, number of events, and potential effects associated with explosives would be the same under Alternatives 1 and 2. • Energy: The locations, number of events, and potential effects associated with energy stressors would be the same under Alternatives 1 and 2. • Physical Disturbance and Strikes: Under Alternative 2, potential physical disturbance and strike impacts to invertebrates associated with training and testing activities would be similar to those discussed for activities under Alternative 1. The total area affected for all training and testing activities combined would increase by less than 1 acre under Alternative 2. There would be a very small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on invertebrates. • Entanglement: There would be a small increase in the number of military expended materials associated with Alternative 2 activities. However, the increase is negligible and the potential impacts from wires and cables, decelerators/parachutes, and biodegradable polymer under Alternative 2 would be similar to that of Alternative 1. • Ingestion: Under Alternative 2, the locations and types of military expended materials used would be the same as those of Alternative 1. There would be an increase in the number of some items expended, such as targets, sonobuoys, bathythermograph equipment, and small decelerators/parachutes. This relatively small increase in the total number of items expended would not be expected to result in substantive changes to the type or degree of impacts to invertebrates. • Secondary Stressors: Secondary impacts on invertebrates resulting from Alternative 2 activities would be nearly identical to those for Alternative 1.
Section 3.5-Habitats	The Navy considered all potential stressors that habitats could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **No Action Alternative:** • Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various ingestion stressors (e.g., military expended materials other than munitions) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. **Alternative 1 (Preferred Alternative):** • Acoustics: Acoustic stressors are not applicable to habitats, due to the fact that habitats do not have hearing capabilities, and are not analyzed in this section. • Explosives: Most explosives would detonate in air or at or near the water surface. Some explosives would be placed on the bottom. Explosive detonations on or near the bottom would produce percussive energy that could impact bottom habitat. While hard bottom would mostly reflect the energy, a crater would form in soft bottom. On substrates other than clay, the effects would be temporary, whereas craters in clay may be persistent. Craters in soft bottom, where substrate moves around

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.5-Habitats (continued)	with the tides and currents, would only last for days to weeks. The surface area of bottom substrate affected would be a tiny fraction of the total training and testing area available in the Study Area. • Energy: Energy stressors are not applicable to habitats because of the lack of sensitivity of habitats and are not analyzed in this section. • Physical Disturbance and Strikes: Most seafloor devices would be placed in areas that would result in minor and temporary bottom substrate impacts. Once on the seafloor and over time, military expended material would be buried by sediment, corroded from exposure to the marine environment, or colonized by benthic organisms. The surface area of bottom substrate affected over the short-term would be a tiny fraction of the total training and testing area available in the Study Area. • Entanglement: Entanglement stressors are not applicable because habitats do not have the ability to become "entangled" by materials. The potential for expended material to cover a substrate is discussed under the physical disturbance and strike stressor. • Ingestion: Ingestion stressors are not applicable because habitats lack the ability to ingest; therefore, ingestion stressors are not analyzed for habitats. • Secondary Stressors: Secondary stressors are not applicable to habitats, as they are not susceptible to impacts from secondary stressors, and are not analyzed further. **Alternative 2:** • Explosives: Explosive activities would be nearly identical under Alternative 2 as those analyzed under Alternative 1, as only the frequency and duration of activities would differ. In-water explosions under Alternative 2 training and testing activities would be limited to local and short-term impacts on marine habitat structure in the AFTT Study Area. • Physical Disturbance and Strikes: Most seafloor devices would be placed in areas that would result in minor and temporary bottom substrate impacts. Once on the seafloor and over time, military expended material would be buried by sediment, corroded from exposure to the marine environment, or colonized by benthic organisms. The surface area of bottom substrate affected over the short-term would be a tiny fraction of the total training and testing area available in the Study Area.
Section 3.6-Fishes	The Navy considered all potential stressors that fishes could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **No Action Alternative:** • Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. The combined impacts of all stressors for fishes would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities and no impacts on fish population would occur. **Alterantive1 (Preferred Alternative):** • Acoustics: The use of sonar and other transducers, air guns, pile driving, vessel noise, aircraft noise, and weapons noise could result in impacts on fishes in the Study Area. Some sonars and other transducers, vessel noise, and weapons noise could

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.6- Fishes (continued)	result in hearing loss, masking, physiological stress, or behavioral reactions. Aircraft noise would not likely result in impacts other than brief, mild behavioral responses in fishes that are close to the surface. Air guns and pile driving have the potential to result in the same effects in addition to mortality or injury. Most impacts, such as masking or behavioral reactions, are expected to be temporary and infrequent as most activities involving acoustic stressors would be at low levels of noise, temporary, localized, and infrequent. More severe impacts such as mortality or injury could lead to permanent or long-term consequences for individuals but, overall, long-term consequences for fish populations are not expected. • Explosives: The use of explosives could result in impacts on fishes within the Study Area. Sound and energy from explosions is capable of causing mortality, injury, hearing loss, masking, physiological stress, or behavioral responses. The time scale of individual explosions is very limited, and training and testing activities involving explosions are dispersed in space and time. Therefore, repeated exposure of individual fishes are unlikely. Most effects such as hearing loss or behavioral responses are expected to be short-term and localized. More severe impacts such as mortality or injury could lead to permanent or long-term consequences for individuals but, overall, long-term consequences for fish populations are not expected. • Energy: The use of electromagnetic devices may elicit brief behavioral or physiological stress responses only in those exposed fishes with sensitivities to the electromagnetic spectrum. This behavioral impact is expected to be temporary and minor. Similar to regular vessel traffic that is continuously moving and covers only a small spatial area during use, electromagnetic fields would be continuously moving and cover only a small spatial area during use, so population-level impacts are unlikely. • Physical Disturbance and Strikes: Vessel strikes, in-water device strikes, military expended material strikes, and seafloor device strikes present a risk for collision with fishes, particularly near coastal areas, seamounts, and other bathymetric features where densities are higher. While the potential for physical disturbance and strikes of fishes can occur anywhere vessels are operated or training and testing activities occur, most fishes are highly mobile and have sensory capabilities which enable the detection and avoidance of vessels, expended materials, or objects in the water column or on the seafloor. • Entanglement: Fishes could be exposed to multiple entanglement stressors associated with Navy training and testing activities. The potential for impacts is dependent on the physical properties of the expended materials and the likelihood that a fish would encounter a potential entanglement stressor and then become entangled in it. Physical characteristics of wires and cables, decelerators/parachutes, and biodegradable polymers, combined with the sparse distribution of these items throughout the Study Area, indicates a very low potential for fishes to encounter and become entangled in them. Because of the low numbers of fish potentially impacted by entanglement stressors, population-level impacts are unlikely. • Ingestion: The likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish and the rate at which the fish encounters the item and the composition of the item. Military expended materials from munitions present an ingestion risk to fishes that forage in the water column and on the seafloor. Military expended materials other than munitions present an ingestion risk for fishes foraging at or near the surface while these materials are buoyant, and on the seafloor when the materials sink. Because of the low numbers of fish potentially impacted by ingestion stressors, population-level impacts are unlikely.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.6-Fishes (continued)	• Secondary Stressors: Effects on sediment or water quality would be minor, temporary, and localized and could have short-term, small-scale secondary effects on fishes; however, there would be no persistent or large-scale effects on the growth, survival, distribution, or population-level of fishes. **Alternative 2:** • Acoustics: Potential impacts to fishes would be similar to those discussed for training activities under Alternative 1. The only difference in sonar and other transducer use between Alternatives 1 and 2 is that the number of sonar hours used would be greater under Alternative 2. Air guns and pile driving impacts would be the same under Alternative 2. Potential impacts resulting from vessel noise would be similar to those discussed for activities under Alternative 1. Vessel use in the Study Area would increase by a very small amount (about one percent). The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2, however, the types and severity of impacts would not be discernible from those described under Alternative 1. • Explosives: The locations, number of events, and potential effects associated with explosives would be the same under Alternatives 1 and 2. • Energy: The locations, number of events, and potential effects associated with energy stressors would be the same under Alternatives 1 and 2. • Physical Disturbance and Strikes: Under Alternative 2, potential physical disturbance and strike impacts to fishes associated with training and testing activities would be similar to those discussed for activities under Alternative 1. There would be a very small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on fishes. • Entanglement: There would be a small increase in the number of military expended materials associated with Alternative 2 activities. However, the increase is negligible and the potential impacts from wires and cables, decelerators/parachutes, and biodegradable polymer under Alternative 2 would be similar to that of Alternative 1.
Section 3.7-Marine Mammals	The Navy considered all stressors that marine mammals could be exposed to from the Proposed Action. The following conclusions have been reached for the following stressors under the project alternatives: **No Action Alternative:** • Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various secondary stressors would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. **Alternative 1 (Preferred Alternative):** • Acoustics: Navy training and testing activities have the potential to expose marine mammals to multiple acoustic stressors. Exposure to sound-producing activities presents risks to marine mammals that could include temporary or permanent hearing threshold shift, auditory masking, physiological stress, or behavioral responses. Because individual animals would typically only experience a small number of behavioral responses or temporary hearing threshold shifts per year from exposure to acoustic

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.7-Marine Mammals (continued)	stressors and are unlikely to incur substantive costs to the individual, population level effects are unlikely. • <u>Explosives:</u> Explosions underwater or near the surface present a risk to marine mammals located in close proximity to the explosion, because the resulting shock waves can cause injury or result in the death of an animal. Beyond the zone of injury, the impulsive, broadband noise introduced into the marine environment may cause temporary or permanent hearing threshold shift, auditory masking, physiological stress, or behavioral responses. Because most estimated impacts from explosions are behavioral responses or temporary threshold shifts (TTS) and because the number of marine mammals potentially impacted by explosives are small compared to each species' respective abundance, population level effects are unlikely. • <u>Energy</u>: Navy training and testing activities have the potential to expose marine mammals to multiple energy stressors. The likelihood and magnitude of energy impacts depend on the proximity of marine mammals to energy stressors. Based on the relatively weak strength of the electromagnetic field created by Navy activities, a marine mammal would have to be in close proximity for there to be any effect, and impacts on marine mammal migrating behaviors and navigational patterns are not anticipated. Potential impacts from high-energy lasers would only result for marine mammals directly struck by the laser beam. Statistical probability analyses demonstrate with a high level of certainty that no marine mammals would be struck by a high-energy laser. Energy stressors associated with Navy training and testing activities are temporary and localized in nature and, based on patchy distribution of animals, no impacts to individual marine mammals and marine mammal populations are anticipated. • <u>Physical Disturbance and Strike:</u> Marine mammals would potentially be exposed to multiple physical disturbance and strike stressors associated with Navy training and testing activities. The potential for impacts relies heavily on the probability that marine mammals would be in close proximity to a physical disturbance and strike stressor (e.g., a vessel or a non-explosive munition). Historical data on Navy ship strike records demonstrate a low occurrence of interactions with marine mammals over the last 10 years. Since the Navy does not anticipate a change in the level of vessel use compared to the last decade, the potential for striking a marine mammal remains low. Physical disturbance due to vessel movement and in-water devices, but any stress response of avoidance behavior would not be severe enough to have long-term fitness consequences for individual marine mammals. The use of in-water devices during Navy activities involves multiple types of vehicles or towed devices traveling on the water surface, through the water column, or along the seafloor, all of which having the potential to disturb or physically strike marine mammals. No recorded or reported instances of marine mammal strikes have resulted from in-water devices; therefore, impacts to individuals or long-term consequences to marine mammal populations are not anticipated. Potential physical disturbance and strike impacts from military expended materials and seafloor devices are determined through statistical probability analyses. Results for each of these physical disturbance and strike stressors suggests a very low potential for marine mammals to be struck by any of these items. Long-term consequences to marine mammal populations from physical disturbance and strike stressors associated with Navy training and testing activities are not anticipated. • <u>Entanglement:</u> Marine mammals could be exposed to multiple entanglement stressors associated with Navy training and testing activities. The potential for impacts is dependent on the physical properties of the expended materials and the likelihood that a marine mammal would encounter a potential entanglement stressor and then become entangled in it. Physical characteristics of

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.7-Marine Mammals (continued)	wires and cables, decelerators/parachutes, and biodegradable polymers combined with the sparse distribution of these items throughout the Study Area indicate a very low potential for marine mammals to encounter and become entangled in them. Long-term impacts to individual marine mammals and marine mammal populations from entanglement stressors associated with Navy training and testing activities are not anticipated. • Ingestion: Navy training and testing activities have the potential to expose marine mammals to multiple ingestion stressors and associated impacts. The likelihood and magnitude of impacts depend on the physical properties of the military expended items, the feeding behaviors of marine mammals that occur in the Study Area, and the likelihood that a marine mammal would encounter and incidentally ingest the items. Adverse impacts from ingestion of military expended materials would be limited to the unlikely event that a marine mammal would be harmed by ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system. The likelihood that a marine mammal would encounter and subsequently ingest a military expended item associated with Navy training and testing activities is considered low. Long-term consequences to marine mammal populations from ingestion stressors associated with Navy training and testing activities are not anticipated. • Secondary Stressors: Marine mammals could be exposed to multiple secondary stressors (indirect stressors to habitat or prey) associated with Navy training and testing activities in the Study Area. In-water explosions have the potential to injure or kill prey species that marine mammals feed on within a small area affected by the blast; however, impacts would not substantially impact prey availability for marine mammals. Explosion byproducts and unexploded munitions would have no meaningful effect on water or sediment quality; therefore, they are not considered to be secondary stressors for marine mammals. Metals are introduced into the water and sediments from multiple types of military expended materials. Available research indicates metal contamination is very localized and that bioaccumulation resulting from munitions would not occur. Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in concentration; however, through rapid dilution, toxic concentrations are unlikely to be encountered by marine mammals. Furthermore, bioconcentration or bioaccumulation of chemicals introduced by Navy activities at levels that would significantly alter water quality and degrade marine mammal habitat has not been documented. The Navy's use of marine mammals is not likely to increase the risk of transmitting diseases or parasites to wild marine mammals. Secondary stressors from Navy training and testing activities in the Study Area are not expected to have short-term impacts on individual marine mammals or long-term impacts on marine mammal populations. **Alternative 2:** • Acoustics: Potential impacts to marine mammals would be similar to those discussed for training activities under Alternative 1. The only difference in sonar and other transducer use between Alternatives 1 and 2 is that the number of sonar hours used would be greater under Alternative 2. Air guns and pile driving impacts would be the same under Alternative 2. Potential impacts resulting from vessel noise would be similar to those discussed for activities under Alternative 1. Vessel use in the Study Area would increase by a very small amount (about one percent). The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While the types of expected impacts to on any individual marine mammal would remain the same, more animals could be affected.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.7- Marine Mammals (continued)	• Explosives: The locations, number of events, and potential effects associated with explosives would be the same under Alternatives 1 and 2. • Energy: The locations, number of events, and potential effects associated with energy stressors would be the same under Alternatives 1 and 2. • Physical Disturbance and Strikes: Under Alternative 2, potential physical disturbance and strike impacts to marine mammals associated with training and testing activities would be similar to those discussed for activities under Alternative 1. There would be a very small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on marine mammals. • Entanglement: There would be a small increase in the number of military expended materials associated with Alternative 2 activities. However, the increase is negligible and the potential impacts from wires and cables, decelerators/parachutes, and biodegradable polymer under Alternative 2 would be similar to that of Alternative 1. • Ingestion: Under Alternative 2, the locations and types of military expended materials used would be the same as those of Alternative 1. There would be an increase in the number of some items expended, such as targets, sonobuoys, bathythermograph equipment, and small decelerators/parachutes. This relatively small increase in the total number of items expended would not be expected to result in substantive changes to the type or degree of impacts to marine mammals. • Secondary Stressors: Secondary impacts on marine mammals resulting from Alternative 2 activities would be nearly identical to those from Alternative 1.
Section 3.8- Reptiles	The Navy considered all potential stressors that reptiles could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **No Action Alternative:** • Under the No Action Alternative, training and testing activities associated with the Proposed Action will not be conducted within the AFTT Study Area. Under this alternative, there would be no potential for impacts on sea turtles. The cessation of some stressors would be more beneficial than others. For instance, because of the localized and short-term duration of any potential impact from an electromagnetic field on a sea turtle, the potential benefits to sea turtles is not likely measureable. The removal of fast vessel movement training activities, however, would likely decrease behavioral impacts and responses to vessels, but again, the impact is likely short-term, with normal behaviors resuming within minutes of a passing vessel. Vessel strike risk would be reduced, which would likely increase survivability and individual fitness for a small number of sea turtles or crocodilians. Further, the synergistic effects of multiple stressors would not occur, thereby providing benefits to sea turtles and crocodilians by removing short-term and long-term potential impacts. The implementation of the No Action Alternative would remove risks of impacts associated with training and testing activities; however, monitoring data accumulated through range sustainment programs would cease. These data provide foundational data for the research and regulatory communities to assess ongoing threats and conservation status of various species.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.8- Reptiles (continued)	**<u>Alternative 1 (Preferred Alternative):</u>** • <u>Acoustics:</u> Navy training and testing activities have the potential to expose reptiles to multiple types of acoustic stressors, including sonars, other transducers, air guns, pile driving, and vessel, aircraft, and weapons noise. Reptiles could be affected by only a limited portion of acoustic stressors because reptiles have limited hearing abilities. Exposures to sound-producing activities present risks that could range from hearing loss, auditory masking, physiological stress, and changes in behavior; however, no injurious impacts are predicted due to exposure to any acoustic stressor. Because the number of sea turtles potentially impacted by sound-producing activities is small, population level effects are unlikely. Few, if any impacts on crocodilians or terrapins are anticipated from acoustic stressors because of the location of training activities relative to crocodilian and terrapin habitats. • <u>Explosives</u>: Explosions in the water or near the water's surface present a risk to reptiles located in close proximity to the explosion, because the shock waves produced by explosives could cause injury or result in the death. If further away from the explosion, impulsive, broadband sounds introduced into the marine environment may cause hearing loss, auditory masking, physiological stress, or changes in behavior. Sea turtles would be exposed to explosive stressors in the nearshore and offshore portions of the Study Area, while crocodilians and terrapins would be exposed to explosive stressors at two inshore training and testing locations. One loggerhead sea turtle mortality is predicted. Because the number of sea turtles potentially impacted by explosives is small, population-level effects are unlikely. It is unlikely that crocodilians and terrapins would be in close proximity to inshore explosions because they would likely, if present, flee the area in response to other stressors (e.g., vessel noise, visual stimulus). Also, the types of explosives are small limpet mine charges, which limits the area where crocodilians and terrapins could be exposed to injurious impacts from explosives. Because inshore explosives training activities would impact few, if any, crocodilians or terrapins, population-level effects are unlikely. • <u>Energy:</u> Navy training and testing activities have the potential to expose reptiles to multiple energy stressors in offshore and inshore training and testing locations. The likelihood and magnitude of energy impacts depends on the proximity of a reptile to energy stressors. Based on the relatively weak strength of the electromagnetic field created by Navy activities, impacts on sea turtles migrating behaviors and navigational patterns are not anticipated. Potential impacts from high-energy lasers would only result for sea turtles directly struck by the laser beam. Statistical probability analyses demonstrate with a high level of certainty that no sea turtles would be struck by a high-energy laser. Activities that generate electromagnetic fields would occur in inshore habitats potentially inhabited by crocodilians and terrapins; however, no measureable impacts on individuals would be expected to occur. Activities using high-energy lasers would not occur in inshore training and testing locations Energy stressors associated with Navy training and testing activities are temporary and localized in nature, and based on patchy distribution of animals, no impacts on individual reptile or reptile populations are anticipated. • <u>Physical Disturbance and Strikes:</u> Vessels, in-water devices, and seafloor devices present a risk for collision with sea turtles, particularly in coastal areas where densities are higher. Strike potential by expended materials is statistically small. Because of the low numbers of sea turtles potentially impacted by activities that may potentially cause a physical disturbance and strike, population level effects are unlikely. Activities that use vessels, in-water devices, and seafloor devices would occur in habitats

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.8-Reptiles (continued)	used by crocodilians and terrapins. Activities that expend materials would also occur in inshore habitats inhabited by crocodilians and terrapins; however, interactions with materials would not likely occur, and no impacts on individual crocodilians and terrapins are expected if a reptile encountered expended material. Because of the low numbers of crocodilians and terrapins potentially impacted by activities that may potentially cause a physical disturbance and strike, population-level effects are unlikely. • Entanglement: Sea turtles could be exposed to multiple entanglement in inshore and offshore training and testing locations. The potential for impacts is dependent on the physical properties of the expended materials and the likelihood that a sea turtle would encounter a potential entanglement stressor and then become entangled in it. Physical characteristics of wires and cables, decelerators/parachutes, and biodegradable polymers combined with the sparse distribution of these items throughout the Study Area indicates a very low potential for sea turtles to encounter and become entangled in them. Long-term impacts on individual sea turtles and sea turtle populations from entanglement stressors associated with Navy training and testing activities are not anticipated. Entanglement stressors are not anticipated to impact crocodilians or terrapins because activities that expend materials that present a potential entanglement risk would not co-occur with crocodilian or terrapins habitats. • Ingestion: Navy training and testing activities have the potential to expose reptiles to multiple ingestion stressors and associated impacts in inshore and offshore training and testing locations. The likelihood and magnitude of impacts depends on the physical properties of the military expended items and the feeding behaviors of the particular species of reptiles that occur in specific areas where potentially ingestible items are used. Adverse impacts from ingestion of military expended materials would be limited to the unlikely event that a sea turtle, crocodilian, or terrapin would be harmed by ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system. The likelihood that a reptile would encounter and subsequently ingest a military expended item associated with Navy training and testing activities is considered low. Long-term consequences to reptile populations from ingestion stressors associated with Navy training and testing activities are not anticipated. • Secondary Stressors: Reptiles could be exposed to multiple secondary stressors (indirect stressors to habitat or prey) associated with Navy training and testing activities in the Study Area. In-water explosions have the potential to injure or kill prey species that sea turtles feed on within a small area affected by the blast; however, impacts would not substantially. impact prey availability for sea turtles, crocodilians, or terrapins. Explosion byproducts and unexploded munitions would have no meaningful effect on water or sediment quality; therefore they are not considered to be secondary stressors for reptiles. Metals are introduced into the water and sediments from multiple types of military expended materials. Available research indicates metal contamination is very localized and that bioaccumulation resulting from munitions would not occur. Several Navy training and testing activities introduce chemicals into the offshore and inshore environments that are potentially harmful in concentration; however, through rapid dilution, toxic concentrations are unlikely to be encountered by sea turtles, crocodilians, or terrapins. Furthermore, bioconcentration or bioaccumulation of chemicals introduced by Navy activities to levels that would significantly alter water quality and degrade sea turtle habitat has not been documented. Secondary stressors from Navy training and testing activities in the Study Area are not expected to have short-term impacts on individual sea turtles

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.8-Reptiles (continued)	or long-term impacts on sea turtle populations. Secondary stressors discussed above would overlap with crocodilian and terrapin habitats at inshore training locations. As with sea turtles, toxic concentrations of chemicals and munitions constituents are unlikely to be encountered by crocodilians and terrapins; therefore, bioconcentration or bioaccumulation of chemicals introduced by Navy activities would not likely alter water quality, degrade habitats, or reduce prey availability. Any indirect stressors to habitat or prey from training and testing activities are anticipated to be negligible, and no population-level impacts are anticipated. **Alternative 2:** • Acoustics: Potential impacts to reptiles would be similar to those discussed for training activities under Alternative 1. The only difference in sonar and other transducer use between Alternatives 1 and 2 is that the number of sonar hours used would be greater under Alternative 2. Air guns and pile driving impacts would be the same under Alternative 2. Potential impacts resulting from vessel noise would be similar to those discussed for activities under Alternative 1. Vessel use in the Study Area would increase by a very small amount (about one percent). The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While the types of expected impacts to any individual reptile would remain the same, more animals could be affected. • Explosives: The locations, number of events, and potential effects associated with explosives would be the same under Alternatives 1 and 2. • Energy: The locations, number of events, and potential effects associated with energy stressors would be the same under Alternatives 1 and 2. • Physical Disturbance and Strike: Under Alternative 2, potential physical disturbance and strike impacts to reptiles would be similar to those discussed for activities under Alternative 1. There would be a very small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on reptiles. • Entanglement: There would be a small increase in the number of military expended materials associated with Alternative 2 activities. However, the increase is negligible and the potential impacts from wires and cables, decelerators/parachutes, and biodegradable polymers under Alternative 2 would be similar to that of Alternative 1. • Ingestion: Under Alternative 2, the locations and types of military expended materials used would be the same as those of Alternative 1. There would be an increase in the number of some items expended, such as targets, sonobuoys, bathythermograph equipment, and small decelerators/parachutes. This relatively small increase in the total number of items expended would not be expected to result in substantive changes to the type or degree of impacts to reptiles. • Secondary Stressors: Secondary impacts on reptiles resulting from Alternative 2 training and testing activities would be nearly identical to those from Alternative 1.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

<table>
<tr><th>Resource Category</th><th>Summary of Impacts</th></tr>
<tr><td>Section 3.9-
Birds and Bats</td><td>The Navy considered all potential stressors that birds and bats could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives:
<u>No Action Alternative:</u>
• Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various stressors would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.
<u>Alternative 1 (Preferred Alternative):</u>
• <u>Acoustics</u>: Navy training and testing activities have the potential to expose birds and bats to a variety of acoustic stressors. The exposure to underwater sounds by birds depends on the species and foraging method. Pursuit divers may remain underwater for minutes, increasing the chance of underwater sound exposure. The exposure to in-air sounds by birds and bats depends on the activity (in flight or on the water surface) and the proximity to the sound source. Because birds are less susceptible to both temporary and permanent threshold shift than mammals, unless very close to an intense sound source, responses by birds to acoustic stressors would likely be limited to short-term behavioral responses. Some birds may be temporarily displaced and there may be temporary increases in stress levels. Although individual birds may be impacted, population level impacts are not expected. Unlike other mammals, bats are not susceptible to temporary and permanent threshold shifts. Bats may be temporarily displaced during foraging, but would return shortly after the training or testing is complete. Although individual bats may be impacted, population level impacts are not expected.
• <u>Explosives:</u> Navy training and testing activities have the potential to expose birds and bats to explosions in the water, near the water surface, and in air. Sounds generated by most small underwater explosions are unlikely to disturb birds and bats above the water surface. However, if a detonation is sufficiently large or is near the water surface, birds and bats above the pressure released at the air-water interface could be injured or killed. Detonations in air could injure birds and bats while either in flight or at the water surface; however, detonations in air during anti-air warfare training and testing would typically occur at much higher altitudes where seabirds, migrating birds, and bats are less likely to be present. Detonations may attract birds to possible fish kills, which could cause bird mortalities or injuries if there are multiple detonations in a single event. An explosive detonation would likely cause a startle reaction, as the exposure would be brief and any reactions are expected to be short-term. Although a few individuals may experience long-term impacts and potential mortality, population-level impacts are not expected.
• <u>Energy:</u> The impact of energy stressors on birds and bats is expected to be negligible based on (1) the limited geographic area in which they are used, (2) the rare chance that an individual bird or bat would be exposed to these devices in use, and (3) the tendency of birds and bats to temporarily avoid areas of activity when and where the devices are in use. The impacts of energy stressors would be limited to individual cases where a bird or bat might become temporarily disoriented and change flight direction, or be injured. Although a small number of individuals may be impacted, the impact at the population level would be negligible.</td></tr>
</table>

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.9-Birds and Bats (continued)	• <u>Physical Disturbance and Strikes:</u> There is the potential for individual birds to be injured or killed by physical disturbance and strikes during training and testing. However, there would not be long-term species or population level impacts due to the vast area over which training and testing activities occur and the small size of birds and their ability to flee disturbance. Impacts to bats would be similar to, but less than, those described for birds since bat occurrence in the Study Area is relatively scant compared to birds and because bats are most active from dusk through dawn. • <u>Entanglement:</u> Entanglement stressors have the potential to impact birds. However, the likelihood is low because the relatively small quantities of materials that could cause entanglement would be dispersed over very wide areas, often in locations or depth zones outside the range or foraging abilities of most birds. A small number of individuals may be impacted, but no effects at the population level would be expected. The possibility that an individual of an ESA-listed bird species would become entangled is remote due to their rarity and limited overlap with Navy activities. Since bats considered in this analysis do not occur in the water column and rarely occur at the water surface in the Study Area, few, if any, impacts to bats are anticipated from entanglement stressors. • <u>Ingestion:</u> It is possible that persistent expended materials could be accidentally ingested by birds while they were foraging for natural prey items, though the probability of this event is low as (1) foraging depths of diving birds is generally restricted to the surface of the water or shallow depths, (2) the material is unlikely to be mistaken for prey, and (3) most of the material remains at or near the sea surface for a short length of time. No population-level effect to any bird species would be anticipated. Since bats considered in this analysis do not occur in the water column and rarely feed at the water surface in the Study Area, few, if any, impacts to bats are anticipated from ingestion stressors. • <u>Secondary Stressors</u>: There would be relatively localized, temporary impacts from water quality (turbidity) which may alter foraging conditions, but no impacts on prey availability. Since bats considered in this analysis do not occur in the water column and rarely occur at the water surface in the Study Area, few, if any, impacts to bats are anticipated from secondary stressors. **<u>Alternative 2:</u>** • <u>Acoustics:</u> Alternative 2 has an increase in sonar use compared to Alternative 1; however, potential impacts from Alternative 2 activities would be similar to those as Alternative 1. Air guns and pile driving impacts would be the same under Alternative 2. Potential impacts resulting from vessel noise would be similar to those discussed for activities under Alternative 1. Vessel use in the Study Area would increase by a very small amount. The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While individual birds or bats may be impacted by training or testing activities, population level impacts are not expected.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

<table>
<tr><th>Resource Category</th><th>Summary of Impacts</th></tr>
<tr><td>Section 3.9-Birds and Bats (continued)</td><td>
<u>Explosives:</u> There would be a minor increase in explosives use under Alternative 2 compared to Alternative 1; however, the types of potential impacts and locations of impacts would be the same as those described under Alternative 1. Most impacts to individual birds and bats, if any, are expected to be minor and limited. Although a few individuals may experience long-term impacts and potential mortality, population-level impacts are not expected, and explosives will not have a significant adverse effect on populations of migratory bird species.
<u>Energy:</u> The number and distribution of training and testing activities using in-water electromagnetic devices under Alternative 2 would differ slightly from Alternative 1; however, the difference is inconsequential and the impacts would be essentially the same as for Alternative 1. The use of high energy lasers under Alternative 2 would be the same as under Alternative 1; therefore, impacts would be the same.
<u>Physical Disturbance and Strikes:</u> Under Alternative 2, potential impacts to birds or bats resulting from training and testing activities would be slightly greater but would still be inconsequential due to the relatively small number of individuals affected and the lack of population-level effects.
<u>Entanglement:</u> Under Alternative 2, increases in sonobuoy component release and the number of decelerators/parachutes that would be expended would proportionally increase the possibility of entanglement relative to Alternative 1. However, the likelihood of injury or mortality is still considered negligible, and the potential impacts from Alternative 2 activities would be the same as for Alternative 1.
<u>Ingestion</u>: Activities under Alternative 2 would generate the same types of ingestible materials generated under Alternative 1. While the quantities and locations of some expended materials would change slightly, the vast majority would be the same as under Alternative 1. Therefore, the implementation of Alternative 2 would have similar impacts to those of training and testing activities under Alternative 1.
<u>Secondary Stressors:</u> Potential impacts from secondary stressors under Alternative 2 would be the same as Alternative 1.
</td></tr>
<tr><td>Section 3.10-Cultural Resources</td><td>The Navy considered all potential stressors that cultural resources could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives:
<u>No Action Alternative:</u>
Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities. Baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.
<u>Alternative 1 (Preferred Alternative):</u>
<u>Explosive:</u> Explosive stressors resulting from underwater explosions creating shock waves and cratering of the seafloor would not result in adverse effects to known submerged cultural resources. Therefore, no submerged cultural resources are expected to be affected.
<u>Physical Disturbance and Strikes:</u> Physical disturbance and strike stressors resulting from in water devices, military expended materials, seafloor devices, pile driving, and vibration from sonic booms during training and testing activities would not result in
</td></tr>
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Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	*Summary of Impacts*
Section 3.10-Cultural Resources (continued)	adverse effects to known or unknown submerged cultural resources. Therefore, no submerged cultural resources are expected to be affected. **Alternative 2:** • Explosive: Under Alternative 2, training activities (including the use of explosives) would remain the same as those described under Alternative 1; therefore, potential impacts are expected to be the same as Alternative 1. • Physical Disturbance and Strikes: Under Alternative 2, the number of training activities using in-water devices is the same as under Alternative 1; therefore, potential impacts are expected to be the same as Alternative 1.
Section 3.11 – Socioeconomic Resources	The Navy considered all potential stressors that socioeconomics could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **No Action Alternative:** • Under the No Action Alternative, training and testing activities associated with the Proposed Action will not be conducted within the AFTT Study Area. Therefore, training and testing activities would not limit accessibility to air and sea space (although other Navy activities would still use established ranges, warning areas, and danger zones), generate airborne noise, or cause physical disturbances and strikes. No impacts on socioeconomic resources from these stressors would occur. Ceasing the proposed training and testing activities may reduce the number and types of jobs available in locations where the Navy is a vital or even the primary economic driver sustaining local communities. The secondary effects from reducing personnel who support Navy training and testing activities could include a decline in local business and a decrease in the need for infrastructure, such as schools. If jobs are relocated, a smaller population may no longer be able to sustain the local economy that developed to support the larger population. While more complex studies at the local level would need to be conducted to quantify potential socioeconomic impacts from ceasing training and testing activities, it is highly likely that many coastal communities would be impacted to varying degrees. **Alternative 1 (Preferred Alternative)** • Accessibility: Limits on accessibility to marine areas used by the public (e.g., fishing areas) in the Navy training and testing areas would be temporary and of short duration (hours). Restrictions would be lifted, and conditions would return to normal upon completion of training and testing activities. Minimal impacts on commercial and recreational fishing and tourism may occur; however, limits on accessibility would not result in a direct loss of income, revenue or employment, resource availability, or quality of experience. No impacts on sources for energy production and distribution, mineral extraction, commercial transportation and shipping, and aquaculture are anticipated. • Airborne Acoustics: Because the majority of Navy training and testing activities are conducted far from where tourism and recreational activities are concentrated, the impact of they are in the general vicinity of airborne noise would be negligible. The public may intermittently hear noise from transiting ships or aircraft overflights if a training or testing activity, but these occurrences would be infrequent. The infrequent exposure to airborne noise would not result in a direct loss of income, revenue or employment, resource availability, or quality of experience. No impacts on sources for energy production and distribution, mineral extraction, commercial transportation and shipping, and aquaculture are anticipated.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	*Summary of Impacts*
Section 3.11 – Socioeconomic Resources (continued)	• Physical Disturbance and Strikes: Because the majority of Navy training and testing activities are conducted farther from shore than where most recreational activities are concentrated, the potential for a physical disturbance or strike affecting recreational fishing or tourism is negligible. In locations where Navy training or testing occurs in nearshore areas (e.g., pierside), the Navy coordinates with civilian organizations to assure safe and unimpeded access and use of those areas. Based on the Navy's standard operating procedures and the large expanse of the testing and training ranges, the likelihood of a physical disturbance or strike disrupting sources for energy production and distribution, mineral extraction, commercial transportation and shipping, commercial and recreational fishing, aquaculture, and tourism would be negligible. Therefore, direct loss of income, revenue or employment, resource availability, or quality of experience would not be expected. **Alternative 2:** • Accessibility: Limits on accessibility to marine areas used by the public could increase under Alternative 2 due to an increase in some training and testing activities. However, the difference in potential impacts to access would be inconsequential. • Airborne Acoustics: The number of activities that could generate airborne noise detectable by the public would increase under Alternative 2. However, the difference in acoustic impacts would be inconsequential. • Physical Disturbance and Strike: Under Alternative 2, potential physical disturbance and strike impacts associated with training and testing activities would be similar to those discussed for activities under Alternative 1. There would be a very small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts.
Section 3.12 – Public Health and Safety	The Navy considered all potential stressors that public health and safety could be exposed to from the Proposed Action. The following conclusions have been reached for the project alternatives: **No Action Alternative:** • Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. There would be no appreciable change in potential impacts on public health and safety under the No Action Alternative, as these activities (currently or as proposed) would be unlikely to affect public health and safety. However, diminished military readiness under the No Action Alternative would adversely affect public health and safety. **Alternative 1 (Preferred Alternative):** • In-Water Energy: Because of the Navy's standard operating procedures, impacts on public health and safety would be unlikely. • In-Air Energy: Because of the Navy's standard operating procedures, impacts on public health and safety would be unlikely. • Physical Interactions: Because of the Navy's standard operating procedures, impacts on public health and safety would be unlikely. • Secondary Stressors (sediments and water quality): Because water and sediment quality impacts would be minimal and temporary, and the Navy would not exceed state or federal water quality standards, impacts on public health and safety would be unlikely.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	***Summary of Impacts***
Section 3.12 – Public Health and Safety (continued)	**Alternative 2:** • In-Water Energy: sonar and explosives would occur in the same locations and the Navy would implement standard operating and safety procedures. Therefore, potential for impacts on public health and safety would be the same as Alternative 1. • In-Air Energy: electromagnetic energy and lasers training and testing activities occur in the same locations and numbers as described under Alternative 1. Therefore, potential impacts on public health and safety would ne same as Alternative 1. • Physical Interactions: the Navy would increase the number of, and adjust the locations of some at-sea training and testing activities. The Navy would implement standard operating procedures, and therefore, the potential for impacts on public health and safety would the same as Alternative 1. • Secondary Stressors (sediments and water quality): Potential impacts to water quality would be temporary and minimal, same as Alternative 1.

The majority of platforms, weapons and systems that were proposed for testing during the 2013-2018 timeframe are the same or very similar to those proposed for testing in the future. However, the Navy projects testing of some platforms, weapons and systems will increase, while others will decrease, as compared to the testing requirements that were proposed for the 2013-2018 timeframe. In comparison, the Navy is projecting a net increase in testing systems that use sonar and a net decrease for explosives use, as proposed under Alternative 1, of this EIS/OEIS.

ES.5.2 Acoustic and Explosive Analysis

Improvements have been made to modeling explosive sources to optimize the analysis process and data handling. Statistical variability in the abundance of marine species were added to the marine species distribution process. The availability of additional systematic survey data as well as improvements to habitat modeling methods used to estimate species density resulted in substantial improvements to the species distribution. Marine species criteria and thresholds were also updated based on NMFS marine mammal criteria for permanent and temporary threshold shift for sonar and other transducers, pile driving, air guns and explosives. The Navy also used the best available science from the large number of behavioral response studies that have been conducted to-date to develop updated behavioral response functions.

ES.6 Cumulative Impacts

Cumulative impacts were analyzed for each resource addressed in Chapter 3 (Affected Environment and Environmental Consequences) for the Action Alternatives in combination with past, present, and reasonably foreseeable future actions. Analysis was not separated by Alternative because the data available for the cumulative effects analysis was mostly qualitative in nature and, from a landscape-level perspective, these qualitative impacts are expected to be generally similar.

In accordance with Council on Environmental Quality guidance (Council on Environmental Quality 1997), the cumulative impacts analysis focused on impacts that are “truly meaningful.” The level of analysis for each resource was commensurate with the intensity of the impacts identified in Chapter 3 (Affected Environment and Environmental Consequences).

ES.6.1 Project and Other Activities Analyzed for Cumulative Impacts

Cumulative analysis includes consideration of past, present, and reasonably foreseeable future actions. For past actions, the cumulative impacts analysis only considers those actions or activities that have had ongoing impacts that may be additive to impacts of the Proposed Action. Likewise, present and reasonably foreseeable future actions selected for inclusion in the analysis are those that may have effects additive to the effects of the Proposed Action as experienced by specific environmental receptors.

The cumulative impacts analysis is not bounded by a specific future timeframe. The Proposed Action includes general types of activities addressed by this EIS/OEIS that are expected to continue indefinitely, and the associated impacts could occur indefinitely. Likewise, some reasonably foreseeable future actions and other environmental considerations addressed in the cumulative impacts analysis are expected to continue indefinitely (e.g., oil and gas production, maritime traffic, commercial fishing). While Navy training and testing requirements change over time in response to world events, it should be recognized that available information, uncertainties, and other practical constraints limit the ability to analyze cumulative impacts for the indefinite future.

ES.6.2 Resource-Specific Cumulative Impact Conclusions

In accordance with Council on Environmental Quality guidance (Council on Environmental Quality, 1997), the following cumulative impacts analysis focuses on impacts that are "truly meaningful." The level of analysis for each resource is commensurate with the intensity of the impacts identified in Chapter 3 (Affected Environment and Environmental Consequences) and/or the level to which impacts from the Proposed Action are expected to mingle with similar impacts from existing activities. A full analysis of potential cumulative impacts is provided for marine mammals and reptiles. Rationale is also provided for an abbreviated analysis of the following resources: air quality, sediments and water quality, vegetation, invertebrates, habitat, fishes, birds and bats, cultural resources, socioeconomics, and public health and safety.

ES.6.2.1 Air Quality

The majority of emissions resulting from the Proposed Action would be released outside of state waters and would quickly disperse in the ocean environment. These emissions would largely disperse rather than concentrate due to meteorological and air chemistry processes, and these emissions could mix with emissions from other vessel traffic and oil and gas production activities. Additionally, activities occurring in state waters would likely impact onshore areas to a greater extent than more distant activities. The incremental additive impacts from combined emissions occurring beyond state water boundaries would be minor, localized, intermittent, and unlikely to contribute to future degradation of the ocean atmosphere in a way that would harm ocean ecosystems or nearshore communities. Thus, based on the analysis presented in Section 3.1 (Air Quality) and given the meteorology of the Study Area, the frequency and isolation of proposed training and testing activities (Tables 2.6-1 through 2.6-4), and the quantities of expected emissions, it is anticipated that the incremental contribution of the Proposed Action beyond state waters, when added to the impacts of all other past, present and reasonably foreseeable future actions will not result in measurable additional impacts on air quality in the Study Area or beyond.

Activities occurring within state waters can be considered as localized with greater frequency and higher probability of combining with past, present and reasonably foreseeable future actions in and adjacent to the areas where the training or testing activity is occurring. With the exception of areas around Jacksonville, Florida where training would occur on the St. Johns River and Naval Station Mayport, these areas are all in attainment. The Jacksonville (Florida)-Brunswick (Georgia) Interstate Air Quality Control Region currently contains a small area designated as nonattainment for sulfur dioxide. An analysis of the emissions from the Proposed Action activities occurring in the Jacksonville, Florida area demonstrated that emissions are well below General Conformity thresholds (Section 3.1 Air Quality). It is anticipated that the incremental contribution of the Proposed Action in the state waters in the Jacksonville, Florida area, when added to the impacts of all other past, present and reasonably foreseeable future actions, would not result in measurable additional impacts on air quality in the Jacksonville (Florida)-Brunswick (Georgia) Interstate Air Quality Control Region. A Record of Non Applicability for Clean Air Act Conformity was prepared and is included in Appendix C, Air Quality Emissions Calculations and Record of Non-Applicability.

The area of greatest emissions in state waters is near the Virginia Capes Operational Area, specifically in the lower Chesapeake Bay, the York River, the James River, and their attendant tributaries. Training activities using small riverine boats and other vessels in this area were not analyzed in prior NEPA documents and account for approximately 2,600 tons per year of nitrogen oxide emissions. This represents about 21% of nitrogen oxide emissions for non-road and miscellaneous area sources in the

Hampton Roads Intrastate Air Quality Control Region, which covers Isle of Wight, James City, Nansemond, Southampton, and York counties and the cities of Chesapeake, Franklin, Hampton, Newport News, Norfolk, Portsmouth, Suffolk, Virginia Beach, and Williamsburg (U.S. Environmental Protection Agency, 2016). While the riverine training activities account for a substantial percentage of nonroad emissions in the region, the area is in attainment for all criteria pollutants and the level of activity has not changed appreciably over time. It is anticipated that these emissions, when added to the impacts of all other past, present and reasonably foreseeable future actions, would not result in measurable additional impacts on air quality in the Study Area or beyond.

ES.6.2.2 SEDIMENTS AND WATER QUALITY

It is possible that Navy stressors would combine with non-Navy stressors, particularly in nearshore areas and bays, such as Narragansett Bay or the Lower Chesapeake Bay, to exacerbate already impacted sediments and water quality. Although impacts may temporarily intermingle with other inputs in areas with degraded existing conditions, most of the Navy impacts to water quality and turbidity are expected to be negligible, isolated, and short-term, with disturbed sediments and particulate matter quickly dispersing within the water column or settling to the seafloor and turbidity conditions returning to background levels. The Proposed Action could incrementally contribute persistent metal and plastic materials primarily to the offshore ocean ecosystems. However, these relatively minute concentrations of Navy stressors are not likely to combine with other past, present, or reasonably foreseeable activities in a way that would cumulatively threaten the water and sediment quality within the Study Area.

ES.6.2.3 VEGETATION

The effects of other past, present, and reasonably foreseeable actions on vegetation occur primarily in the coastal and inshore waters and are associated with coastal development, maritime commerce, and the discharge of sediment and other pollutants. The Proposed Action is not expected to substantially contribute to losses of vegetation that would interfere with recovery in these regions. The incremental contribution of the Proposed Action would be insignificant as most of the proposed activities would occur in the open ocean and other areas where seagrasses and other attached marine vegetation do not grow; impacts would be localized; recovery would occur quickly; and none of the alternatives would compound impacts that have been historically significant to marine vegetation (loss of habitat due to development; nutrient loading; shading; turbidity; or changes in salinity, pH, or water temperature). Although vegetation is impacted by stressors throughout the Study Area, the Proposed Action is not likely to incrementally contribute to population- or ecosystem-level changes in the resource, and it is anticipated that the incremental contribution of the Proposed Action when added to the impacts of all other past, present and reasonably foreseeable future actions would not result in measurable additional impacts on vegetation in the Study Area or beyond.

ES.6.2.4 INVERTEBRATES

Although marine invertebrates are impacted by other stressors in the ocean environment, the Proposed Action is not likely to incrementally contribute to population-level stress and decline of the resource. As impacts would be isolated, localized, and not likely to overlap with other relevant stressors, it is anticipated that the incremental contribution of the Proposed Action when added to the impacts of all other past, present and reasonably foreseeable future actions would not result in measurable additional impacts on invertebrates in the Study Area or beyond.

ES.6.2.5 HABITATS

Although it is anticipated that damage to abiotic soft bottom habitat resulting from the Proposed Action would be limited and would recover, many other activities in the ocean are also impacting ocean bottom habitat. However, it is not likely that past, present, and future impacts would overlap Proposed Action activities in place or time before the craters or other impressions in soft bottom substrate fill in. Based on the analysis presented in Section 3.5 (Habitats) and the reasons summarized above, it is anticipated that the incremental contribution of the Proposed Action, when added to the impacts of all other past, present and reasonably foreseeable future actions, would not result in measurable additional impacts on habitats, including National Marine Sanctuaries, in the Study Area or beyond.

ES.6.2.6 FISHES

The aggregate impacts of past, present, and other reasonably foreseeable future actions contributing multiple water quality, noise, and physical risks to fishes will likely continue to have significant effects on individual fishes and fish populations. However, Navy training and testing activities are generally isolated from other activities in space and time and the majority of the proposed training and testing activities occur over a small spatial scale relative to the entire Study Area, have few participants, and are of a short duration. Thus, although it is possible that the Proposed Action could contribute incremental stressors to a small number of individuals, which would further compound effects on a given individual already experiencing stress, it is not anticipated that the Proposed Action has the potential to put additional stress on entire populations. Therefore, it is anticipated that the incremental contribution of the Proposed Action, when added to the impacts of all other past, present and reasonably foreseeable future actions, would not result in measurable additional significant impacts on fishes in the Study Area or beyond.

ES.6.2.7 MARINE MAMMALS

The aggregate impacts of past, present, and other reasonably foreseeable future actions continue to have significant impacts on some marine mammal species in the Study Area. The Proposed Action could contribute incremental stressors to individuals, which would both further compound effects on a given individual already experiencing stress and, in turn, have the potential to further stress populations, some of which may already be in significant decline or in the midst of stabilization and recovery. However, with the implementation of standard operating procedures reducing the likelihood of overlap in time and space with other stressors and the implementation of mitigation measures reducing the likelihood of impacts, the incremental stressors anticipated from the Proposed Action are not anticipated to be significant.

ES.6.2.8 REPTILES

The aggregate impacts of past, present, and other reasonably foreseeable future actions continue to have significant impacts on all reptile species in the Study Area. The Proposed Action could contribute incremental stressors to individuals, which would further compound effects on a given individual already experiencing stress and, in turn, has the potential to further stress populations in significant decline or recovery efforts thereof. However, with the implementation of standard operating procedures reducing the likelihood of overlap in time and space with other stressors and the implementation of mitigation measures reducing the likelihood of impacts, the incremental stressors anticipated from the Proposed Action are not anticipated to be significant.

ES.6.2.9 Birds and Bats

Although other past, present, and reasonably foreseeable actions individually and collectively cause widespread disturbance and mortality of bird and bat populations across the ocean landscape, the Proposed Action is not expected to substantially contribute to their diminishing abundance, induce widespread behavioral or physiological stress, or interfere with recovery from other stressors. It is anticipated that the incremental contribution of the Proposed Action, when added to the impacts of all other past, present and reasonably foreseeable future actions, would not result in significant impacts on birds and bats in the Study Area or beyond.

ES.6.2.10 Cultural Resources

As discussed in Section 3.10 (Cultural Resources), stressors, including explosive and physical disturbance and strike stressors associated with the Proposed Action would not affect submerged prehistoric sites and submerged historic resources in accordance with Section 106 of the National Historic Preservation Act because mitigation measures have been implemented to protect and avoid these resources (Chapter 5, Mitigation). Furthermore, consultation with the appropriate State Historic Preservation Office will continue, as needed, for cultural resources located within state territorial waters (within 3 NM, with the exception of Texas, Puerto Rico, and Florida [Gulf Coast only], which have a 9 NM limit). The Proposed Action is not expected to result in impacts on cultural resources in the Study Area and likewise would not contribute incrementally to cumulative impacts on cultural resources.

ES.6.2.11 Socioeconomics

The analysis in Section 3.11 (Socioeconomics) indicates that the Proposed Action is not expected to result in impacts to socioeconomic resources in the Study Area and likewise would not contribute incrementally to cumulative socioeconomic impacts.

ES.6.2.12 Public Health and Safety

All Proposed Actions would be accomplished by technically qualified personnel and would be conducted in accordance with applicable Navy, state, and federal safety standards and requirements. The analysis presented in Section 3.12 (Public Health and Safety) indicates that the Proposed Action is not expected to result in impacts on public health and safety and likewise would not contribute incrementally to or combine with other impacts on health and safety within the Study Area.

ES.6.3 Summary of Cumulative Impacts

The Action Alternatives would contribute incremental effects on the ocean ecosystem, which is already experiencing and absorbing a multitude of stressors to a variety of receptors. In general, it is not anticipated that the implementation of the Proposed Action would have meaningful contribution to the ongoing stress or cause significant collapse of any particular marine resource, but it would further cause minute impacts on resources that are already experiencing various degrees of interference and degradation. It is intended that the mitigation measures described in Chapter 5 (Mitigation) will further reduce the potential impacts of the Proposed Action in such a way that they are avoided to the maximum extent practicable and to ensure that impacts do not become cumulatively significant to any marine resource.

Marine mammals and sea turtles are the primary resources of concern for cumulative impacts analysis, however, the incremental contributions of the Proposed Action are not anticipated to meaningfully contribute to the decline of these populations or interfere with the recovery efforts thereof due to the implementation of standard operating procedures that reduce the likelihood of overlap in time and space and mitigation measures as described in Chapter 5 (Mitigation) that reduce the likelihood of impacts to both resources.

The aggregate impacts of past, present, and other reasonably foreseeable future actions have resulted in significant impacts on some marine mammal and all sea turtle species in the Study Area; however, the decline of these species is chiefly attributable to other stressors in the environment, including the synergistic effect of bycatch, entanglement, vessel traffic, ocean pollution, and coastal zone development. The analysis presented in Chapter 4 (Cumulative Impacts) and Chapter 3 (Affected Environment and Environmental Consequences) indicate that the incremental contribution of the Proposed Action to cumulative impacts on air quality, sediments and water quality, vegetation, invertebrates, marine habitats, fishes, birds and bats, cultural and socioeconomic resources, and public health and safety would not significantly contribute to cumulative stress on those resources.

ES.7 MITIGATION

The Navy has been mitigating impacts from military readiness activities on environmental and cultural resources throughout areas where it trains and tests for more than two decades. In coordination with the appropriate regulatory agencies, the Navy developed mitigation measures for the Proposed Action that will effectively avoid or reduce potential impacts and that are practical to implement. Chapter 5 (Mitigation) presents full descriptions of mitigation measures to be implemented, discussions of how the Navy developed and assessed each measure, and discussions of measures considered but eliminated.

Mitigation measures that the Navy will implement under the Proposed Action are organized into two categories: procedural mitigation measures and mitigation areas. The Navy will implement procedural mitigation whenever and wherever training or testing activities involving applicable acoustic, explosive, and physical disturbance and strike stressors occur within the Study Area. Procedural mitigation generally involves: (1) the use of one or more trained Lookouts to observe for specific biological resources (e.g., marine mammals, sea turtles) within a mitigation zone (i.e., area around a stressor), (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 until certain recommencement conditions have been met. Table ES.7-1 contains a brief summary of the mitigation zones and other procedural mitigation measures that the Navy will implement under the Proposed Action. Additional information on procedural mitigation measures is presented in Section 5.3 (Procedural Mitigation to be Implemented).

Mitigation areas are geographic locations within the Study Area where the Navy will implement mitigation measures to: (1) avoid or reduce impacts on biological or cultural resources that are not observable by Lookouts from the water's surface (i.e., resources for which procedural mitigation cannot be implemented), (2) in combination with procedural mitigation, to effect the least practicable adverse impact on marine mammal species or stocks and their habitat, or (3) in combination with procedural mitigation, ensure that the Proposed Action does not jeopardize the continued existence of endangered or threatened species, or result in destruction or adverse modification of critical habitat. Table ES.7-2 contains a summary of the mitigation areas that the Navy will implement under the Proposed Action. Figure ES-2 displays the mitigation areas in the Study Area. Additional information on mitigation areas is presented in Section 5.4 (Mitigation Areas to be Implemented).

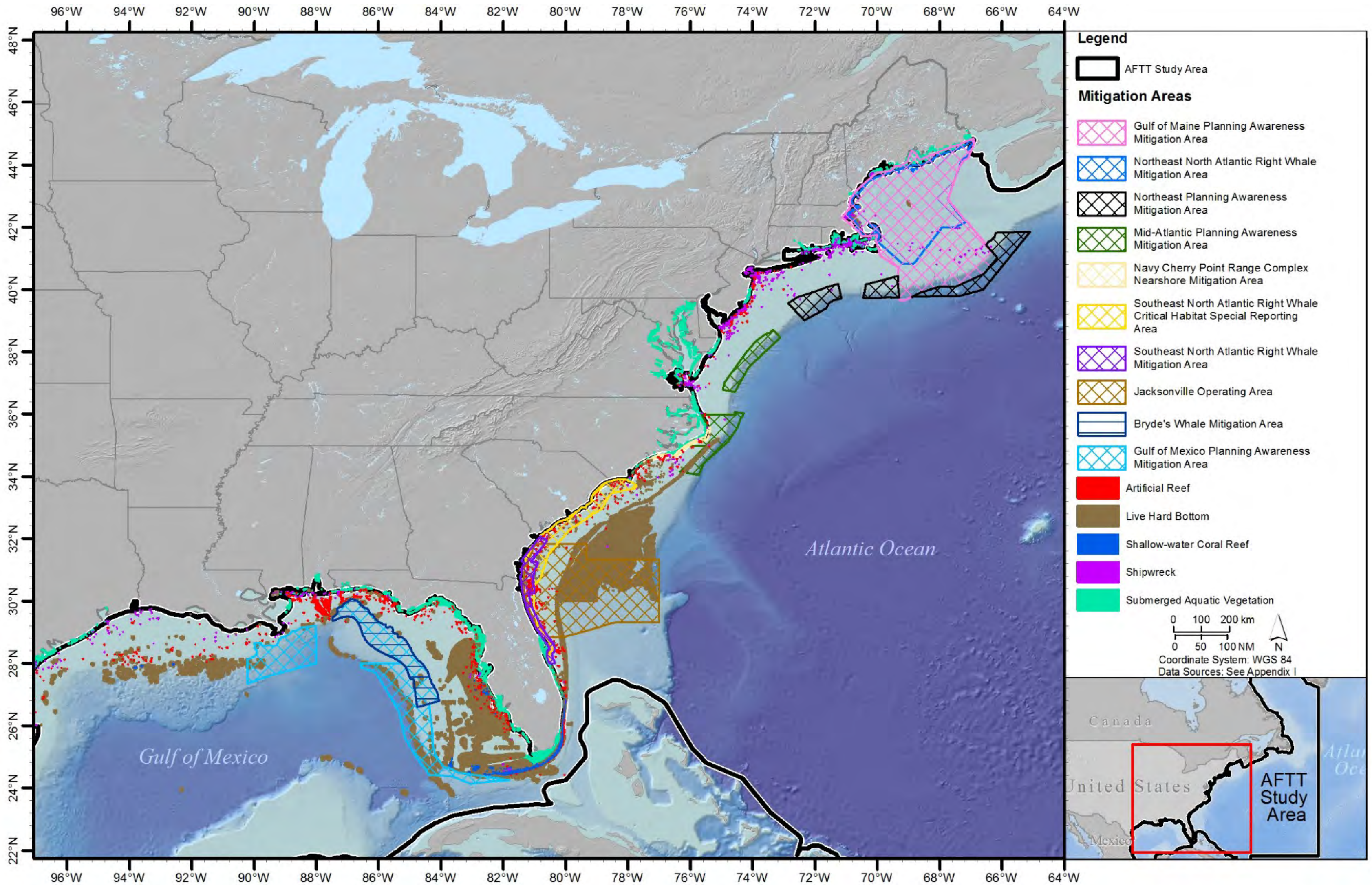
Table ES.7-1: Summary of Procedural Mitigation

Stressor or Activity	*Mitigation Zones Sizes and Other Requirements*	*Protection Focus*
Environmental Awareness and Education	• Afloat Environmental Compliance Training program for applicable personnel	Marine mammals, Sea turtles
Active Sonar	Depending on sonar source: • 1,000 yd. power down, 500 yd. power down, and 200 yd. shut down • 200 yd. shut down	Marine mammals, Sea turtles
Air Guns	• 150 yd.	Marine mammals, Sea turtles
Pile Driving	• 100 yd.	Marine mammals, Sea turtles
Weapons Firing Noise	• 30° on either side of the firing line out to 70 yd.	Marine mammals, Sea turtles
Aircraft Overflight Noise	• Distance from shore in the Virginia Capes Range Complex and Fisherman Island National Wildlife Refuge during explosive mine neutralization activities involving Navy divers (piping plovers and other nesting birds) • Distance from shore in the Dry Tortugas Islands for supersonic flights (Fort Jefferson and roseate terns)	Birds, Cultural resources
Explosive Sonobuoys	• 600 yd.	Marine mammals, Sea turtles
Explosive Torpedoes	• 2,100 yd.	Marine mammals, Sea turtles
Explosive Medium-Caliber and Large-Caliber Projectiles	• 1,000 yd. (large-caliber projectiles) • 600 yd. (medium-caliber projectiles during surface-to-surface activities) • 200 yd. (medium-caliber projectiles during air-to-surface activities)	Marine mammals, Sea turtles
Explosive Missiles and Rockets	• 2,000 yd. (21–500 lb. net explosive weight) • 900 yd. (0.6–20 lb. net explosive weight)	Marine mammals, Sea turtles
Explosive Bombs	• 2,500 yd.	Marine mammals, Sea turtles
Sinking Exercises	• 2.5 NM	Marine mammals, Sea turtles
Explosive Mine Countermeasure and Neutralization Activities	• 2,100 yd. (6–650 lb. net explosive weight) • 600 yd. (0.1–5 lb. net explosive weight)	Marine mammals, Sea turtles
Explosive Mine Neutralization Activities Involving Navy Divers	• 1,000 yd. (21–60 lb. net explosive weight for positive control charges and charges using time-delay fuses) • 500 yd. (0.1–20 lb. net explosive weight for positive control charges)	Marine mammals, Sea turtles
Maritime Security Operations – Anti-Swimmer Grenades	• 200 yd.	Marine mammals, Sea turtles
Line Charge Testing	• 900 yd.	Marine mammals, Sea turtles, Gulf sturgeon
Ship Shock Trials	• 3.5 NM	Marine mammals, Sea turtles
Vessel Movement	• 500 yd. (whales) • 200 yd. (other marine mammals) • Vicinity (sea turtles) • North Atlantic right whale Dynamic Management Area Awareness notification messages	Marine mammals, Sea turtles
Towed In-Water Devices	• 250 yd. (marine mammals) • Vicinity (sea turtles)	Marine mammals, Sea turtles
Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions	• 200 yd.	Marine mammals, Sea turtles
Non-Explosive Missiles and Rockets	• 900 yd.	Marine mammals, Sea turtles
Non-Explosive Bombs and Mine Shapes	• 1,000 yd.	Marine mammals, Sea turtles

Notes: lb. = pound; NM = nautical miles; yd. = yard

Table ES.7-2: Summary of Mitigation Areas

Summary of Mitigation Area Requirements
Mitigation Areas for Shallow-water Coral Reefs
• The Navy will not conduct precision anchoring (except in designated anchorages), explosive or non-explosive mine countermeasure and neutralization activities, explosive or non-explosive mine neutralization activities involving Navy divers, 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, or explosive or non-explosive bombing or mine laying activities. • The Navy will not place mine shapes, anchors, or mooring devices on the seafloor. • Within the Key West Range Complex, 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. • Within the South Florida Ocean Measurement Facility Testing Range, the Navy will implement additional measures for shallow-water coral reefs, such as using real-time positioning and remote sensing information to avoid shallow-water coral reefs during deployment, installation, and recovery of anchors and mine-like objects, and during deployment of bottom-crawling unmanned underwater vehicles.
Mitigation Areas for Live Hard Bottom, Artificial Reefs, Submerged Aquatic Vegetation, and Shipwrecks
• The Navy will not conduct precision anchoring (except in designated anchorages), explosive mine countermeasure and neutralization activities, or explosive mine neutralization activities involving Navy divers, and will not place mine shapes, anchors, or mooring devices on the seafloor. • Within the Key West Range Complex, 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. • Within the South Florida Ocean Measurement Facility Testing Range, the Navy will implement additional measures for live hard bottom, such as using real-time positioning and remote sensing information to avoid live hard bottom during deployment, installation, and recovery of anchors and mine-like objects, and during deployment of bottom-crawling unmanned underwater vehicles.
Northeast North Atlantic Right Whale Mitigation Area
• 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. • The Navy will minimize use of active sonar to the maximum extent practicable and will not use explosives that detonate in the water. • The Navy will conduct non-explosive torpedo testing during daylight hours in Beaufort sea state 3 or less using three Lookouts (one on a vessel, two in an aircraft during aerial surveys) and an additional Lookout on the submarine when surfaced; during transits, ships will maintain a speed of no more than 10 knots; during firing, ships will maintain a speed of no more than 18 knots except brief periods of time during vessel target firing. • Vessels will obtain the latest North Atlantic right whale sightings data and implement speed reductions after they observe a North Atlantic right whale, if within 5 NM of a sighting reported within the past week, and when operating at night or during periods of reduced visibility.
Gulf of Maine Planning Awareness Mitigation Area
• 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. • The Navy will not conduct major training exercises and will not conduct >200 hours of hull-mounted mid-frequency active sonar per year.
Northeast Planning Awareness Mitigation Areas and Mid-Atlantic Planning Awareness Mitigation Areas
• The Navy will avoid conducting major training exercises to the maximum extent practicable. • The Navy will not conduct more than four major training exercises per year.
Southeast North Atlantic Right Whale Mitigation Area (November 15 – April 15)
• 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. • The Navy will not use active sonar except as necessary for navigation training, object detection training, and dipping sonar. • The Navy will not expend explosive or non-explosive ordnance. • Vessels will obtain the latest North Atlantic right whale sightings data; will implement speed reductions after they observe a North Atlantic right whale, if within 5 NM of a sighting reported within the past 12 hours, and when operating at night or during periods of reduced visibility; and will minimize north-south transits to the maximum extent practicable.
Jacksonville Operating Area (November 15 – April 15)
• Navy units conducting training or testing activities in the Jacksonville Operating Area will obtain and use Early Warning System North Atlantic right whale sightings data as they plan specific details of events to minimize potential interactions with North Atlantic right whales to the maximum extent practicable. The Navy will use the reported sightings information to assist their visual observation 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 – April 15)
• 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.



Notes: AFTT: Atlantic Fleet Training and Testing

Figure ES-2: Summary of Mitigation Areas in the Study Area

ES.8 OTHER CONSIDERATIONS

ES.8.1 CONSISTENCY WITH REGULATORY CONSIDERATIONS

Based on an evaluation of consistency with statutory obligations, the Navy's proposed training and testing activities would not conflict with the objectives or requirements of federal, state, regional, or local plans, policies, or legal requirements. The Navy will consult with regulatory agencies as appropriate during the NEPA process and prior to implementation of the Proposed Action to ensure all legal requirements are met.

ES.8.2 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

In accordance with NEPA, this EIS/OEIS provides an analysis of the relationship between a project's short-term impacts on the environment and the effects that these impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. The Proposed Action may result in both short- and long-term environmental effects. However, the Proposed Action would not be expected to result in any impacts that would reduce environmental productivity, permanently narrow the range of beneficial uses of the environment, or pose long-term risks to health, safety, or the general welfare of the public.

ES.8.3 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

For the alternatives including the Proposed Action, most resource commitments are neither irreversible nor irretrievable. Most impacts are short-term and temporary or, if long lasting, are negligible. No habitat associated with threatened or endangered species would be lost as result of implementation of the Proposed Action. Since there would be no building or facility construction, the consumption of materials typically associated with such construction (e.g., concrete, metal, sand, fuel) would not occur. Energy typically associated with construction activities would not be expended and irreversibly lost.

Implementation of the Proposed Action would require fuels used by aircraft and vessels. Since fixed- and rotary-wing flight and ship activities could increase, relative total fuel use could increase. Therefore, if total fuel consumption increased, this nonrenewable resource would be considered irretrievably lost.

ES.8.4 ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL OF ALTERNATIVES

Resources that will be permanently and continually consumed by project implementation include water, electricity, natural gas, and fossil fuels; however, the amount and rate of consumption of these resources would not result in significant environmental impacts or the unnecessary, inefficient, or wasteful use of resources. Prevention of the introduction of potential contaminants is an important component of standard procedures followed by the Navy. To the extent practicable, considerations in the prevention of introduction of potential contaminants are included.

Sustainable range management practices are in place that protect and conserve natural and cultural resources and preserve access to training areas for current and future training requirements while addressing potential encroachments that threaten to impact range and training area capabilities.

ES.9 PUBLIC INVOLVEMENT

The first step in the NEPA process for an EIS is to prepare a Notice of Intent to develop an EIS. The Navy published a Notice of Intent for this EIS/OEIS in the Federal Register and several newspapers on November 12, 2015. In addition, Notice of Intent and Scoping Notification Letters were distributed to federal, state, and local elected officials and government agencies. The Notice of Intent provided an overview of the Proposed Action and the scope of the EIS/OEIS, and initiated the scoping process.

ES.9.1 Scoping Process

Scoping is an early and open process for developing the "scope" of issues to be addressed in an EIS and for identifying significant issues related to a proposed action. During scoping, the public helps define and prioritize issues by providing comments.

Notice of Intent and Scoping Notification letters were distributed at the beginning of the scoping period (November 12, 2015) to federally recognized tribes; state-elected officials; and federal, regional, and state agencies. On the same day, postcards were mailed to 647 recipients on the project mailing list, including individuals, non-profit organizations, and for-profit organizations. The postcards provided information on the Proposed Action, methods for commenting, and the project website address to obtain more information.

To announce the scoping period, advertisements were placed in twenty-three newspapers throughout the AFTT Study Area. The advertisements included a description of the Proposed Action, the address of the project website, the duration of the comment period, and information on how to provide comments.

A project video was developed to support the scoping phase and provide information to the public on the types of training and testing the Navy conducts and its importance. The project video was uploaded to the project website.

ES.9.2 Scoping Comments

The Scoping comments could be submitted via the project website or by mail. The Navy received comments from Federal Agencies, State Agencies, Non-governmental Organizations, individuals and community groups. A total of 72 scoping comments were received. The comments requested the Navy analyze environmental issues from physical and biological resources, such as sonar impacts on marine mammals, to human resources, such as public health and safety. A sampling of some of the specific concerns follows.

- A True No Action Alternative Analysis
- Time-Area Management and Mitigation Areas
- Cumulative Impact Analysis
- Range of Alternatives
- Impacts of Training and Testing to Marine Mammals
- Impacts of Training and Testing to Marine Life

ES.9.3 Public Comments

A Notification of the availability of the AFTT Draft EIS/OEIS for public review and comment was posted in the Federal Register on June 29, 2017. In addition, stakeholder letters were sent to Federal Agencies, State Agencies, Non-governmental Organizations, individuals and community groups. The letters provided a description of the Proposed Action, address of the project website, duration of the comment period, and information on the public meetings. A Notification of Availability of the AFTT Draft EIS/OEIS and public meetings advertisements were placed in twenty-three newspapers located throughout the AFTT study areas. Additional public efforts included the development of six informational videos that were developed and posted on the project website (www.aftteis.com), mailing of more than 500 postcards, six press releases, and five public meetings. Electronic copies of the AFTT Draft EIS/OEIS were also provided to 29 public libraries located throughout the AFTT study area. Comments were received via public comment meetings, internet, and mail from 7 federal agencies, 31 state agencies, 7 local/regional government agencies, 5 non-governmental organizations, 2 tribal governments, 1 commercial group, and 63 private individuals.

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

List of Figures

List of Tables

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ABBREVIATIONS AND ACRONYMS

ACRONYM	DEFINITION
AFTT	Atlantic Fleet Training and Testing
CFR	Code of Federal Regulation
DEIS	Draft Environmental Impact Statement
DoD	Department of Defense
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
MMPA	Marine Mammal Protection Act
Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act

ACRONYM	DEFINITION
NMFS	National Marine Fisheries Service
OEIS	Overseas Environmental Impact Statement
OPAREA	Operating Area
PTS	Permanent Threshold Shift
SEL	Sound Exposure Level
SPL	Sound Pressure Level
TTS	Temporary Threshold Shift
U.S.C.	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

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

TABLE OF CONTENTS

List of Figures

List of Tables

This section does not contain tables.

1 PURPOSE AND NEED

1.1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) proposes to conduct training activities (hereinafter referred to as "training") and research, development, testing, and evaluation (hereinafter referred to as "testing") activities in the Atlantic Fleet Training and Testing (AFTT) Study Area, as represented in Figure 1.2-1. When discussed together, training and testing are also referred to as "military readiness activities." These military readiness activities include the use of active sonar and explosives within existing range complexes and testing ranges, in high seas areas located in the Atlantic Ocean along the eastern coast of North America, in portions of the Caribbean Sea and the Gulf of Mexico, 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 generally consistent with those analyzed in the AFTT Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) completed in August 2013 and are representative of training and testing that the Navy has been conducting in the AFTT Study Area for decades.

The United States is facing increased global disorder, characterized by decline in the long-standing, rules-based international order and creating a more complex and volatile security environment. Major conflicts, terrorism, outlaw actions, and natural disasters all have the potential to threaten national security of the United States. The security, prosperity, and vital interests of the United States are increasingly tied to other nations because of the close relationships between the United States and other national economies. The Navy operates on the world's oceans, seas, and coastal areas—the international maritime domain—on which 90 percent of the world's trade and two-thirds of its oil are transported. The majority of the world's population also lives within a few hundred miles of an ocean. The U.S. Navy carries out training and testing activities to be able to protect the United States against its potential adversaries, to protect and defend the rights and interests of the United States and its allies to move freely on the oceans, and to provide humanitarian assistance.

The Navy has historically used the areas along the eastern coast of the United States and in the Gulf of Mexico for training and testing. These areas have been designated by the Navy as "range complexes" and testing ranges (Figure 1.2-1). Range complexes provide controlled environments where military ship, submarine, and aircraft crews can train in realistic conditions while safely deconflicting with non-military activities, such as civilian shipping and aircraft. The combination of undersea ranges and operating areas (OPAREAs) with land training ranges, divert airfields, and nearshore amphibious landing sites is critical to realistic training and testing. A test range may have electronic instrumentation including radar, optical tracking, and communication systems. Electronics on the ranges capture important data on the effectiveness of tactics and equipment—data that provide a feedback mechanism for training evaluation. While these at-sea areas provide ideal training and testing environments for the Navy, these areas are shared with civilian and commercial vessels and aircraft; these are not areas over which the Navy has exclusive control.

Military readiness activities which prepare the Navy to fulfill its mission to protect and defend the United States and its allies, have the potential to impact the environment. The Navy prepared this EIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions,* by assessing the potential environmental impacts associated with two categories of military readiness activities conducted at sea: training and testing. Collectively, the at-sea areas in this EIS/OEIS are referred to as the AFTT Study Area (Figure 1.2-1).

Training. 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 special warfare) and the community's unique requirements. Personnel then train within their warfare community at sea in preparation for deployment; each warfare community has primary mission areas (areas of specialized expertise that may involve or overlap with multiple warfare communities) that are described in detail in Chapter 2 (Description of Proposed Action and Alternatives).

Testing. The Navy researches, develops, tests, and evaluates new platforms[1], 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.

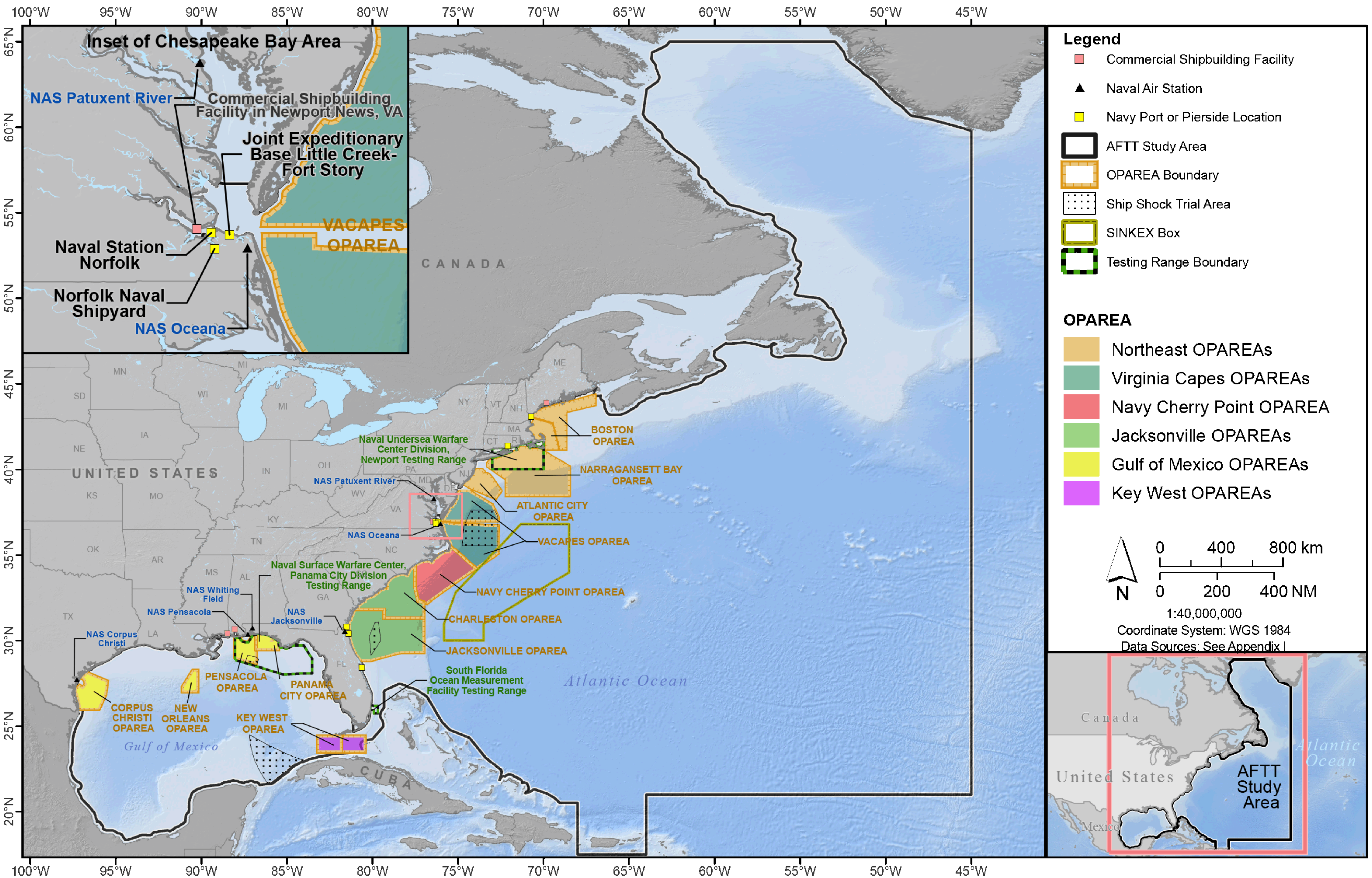
1.2 The Navy's Environmental Compliance and At-Sea Policy

In 2000, the Navy completed a review of its environmental compliance requirements for exercises and training at sea. The Navy then instituted the "At-Sea Policy" to ensure compliance with applicable environmental regulations and policies, and preserve the flexibility necessary for the Navy and Marine Corps to train and test at sea. This policy directed, in part, that Fleet Commanders develop a programmatic approach to environmental compliance at sea for ranges and OPAREAs within their respective geographic areas of responsibility (U.S. Department of the Navy, 2000). Those ranges affected by the "At-Sea Policy" are designated water areas, sometimes containing instrumentation that are managed and used to conduct training and testing activities. Some ranges are further broken down into OPAREAs, to better manage and deconflict military readiness activities.

In 2005, the Navy and the National Oceanic and Atmospheric Administration reached an agreement on a coordinated programmatic strategy for assessing certain environmental effects of military readiness activities at sea. The Navy is currently in the third phase of implementing this programmatic approach.

Phase I of environmental planning. The first phase of the planning program was accomplished by the preparation and completion of individual or separate environmental documents for each range complex and OPAREA. The Navy prepared NEPA/Executive Order 12114 documents for range complexes, testing ranges, and OPAREAs off the east coast and in the Gulf of Mexico—the Atlantic Fleet Active Sonar Training EIS/OEIS, Virginia Capes EIS/OEIS, Cherry Point EIS/OEIS, Jacksonville Range Complex EIS/OEIS, Undersea Warfare Training Range EIS/OEIS, Gulf of Mexico EIS/OEIS, and Naval Surface Warfare Panama City Division EIS/OEIS—to analyze training and testing activities.

[1] Throughout this EIS/OEIS, ships, submarines, and aircraft may be referred to as "platforms"; weapons, combat systems, sensors, and related equipment may be referred to as "systems."



Notes: AFTT: Atlantic Fleet Training and Testing; NAS: Naval Air Station; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 1.2-1: Atlantic Fleet Training and Testing Study Area

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These range complexes pre-date World War II and have been used by U.S. naval forces continuously since then for training and testing activities. Phase I NEPA/Executive Order 12114 documents catalogued training and testing activities; analyzed potential environmental impacts; and supported other requirements under applicable environmental laws, regulations, and executive orders. For example, Marine Mammal Protection Act (MMPA) [16 United States Code (U.S.C.) sections 1361–1407] incidental take authorizations and incidental take statements under the Endangered Species Act (ESA) (16 U.S.C. sections 1531–1544) were issued by the National Marine Fisheries Service (NMFS) to the Navy for range complexes on the east coast and in the Gulf of Mexico and the Naval Surface Warfare Center, Panama City Division testing range in the Gulf of Mexico; those MMPA authorizations began expiring in early 2014.

Phase II of environmental planning. The second phase of the Navy's environmental compliance planning covered activities and existing ranges and OPAREAs previously analyzed in the Phase I NEPA/Executive Order 12114 documents and additional geographic areas including, but not limited to, pierside locations and transit corridors. The Phase II EIS/OEIS for AFTT combined the geographic scope of the range complexes and testing ranges off the east coast and in the Gulf of Mexico, as well as study areas covered in NEPA documents for other at-sea areas on the east coast, and analyzed ongoing, routine at-sea activities that occur during transit between these range complexes, testing ranges, and OPAREAs. The Navy expanded the geographic scope to include additional areas where military readiness activities historically occurred and also included new platforms and systems not addressed in previous NEPA/Executive Order 12114 documents. As was done in Phase I, the Navy used this analysis to support new regulatory consultations and new requests for Letters of Authorization (set to expire in November 2018) under the MMPA and incidental take statements under the ESA.

Phase III of environmental planning. The third phase of the Navy's environmental compliance planning covers similar types of Navy training and testing activities as were analyzed in Phase II. The Navy has re-evaluated impacts from these ongoing activities in existing ranges, OPAREAs, and testing ranges, including activities that occur during transit between these range complexes, testing ranges, and OPAREAs.

Navy has also analyzed new or changing military readiness activities into the reasonably foreseeable future based on evolving operational requirements, including those associated with new platforms and systems not previously analyzed. The Navy has thoroughly reviewed and incorporated into this analysis the best available science relevant to analyzing the environmental impacts of the proposed activities. As with previous Phases, the Navy will use this new analysis to support environmental compliance with other applicable environmental laws, such as the MMPA and ESA.

1.3 PROPOSED ACTION

The Navy's Proposed Action, described in detail in Chapter 2 (Description of Proposed Action and Alternatives), is to conduct military readiness activities in the western Atlantic Ocean off the east coast of the United States, in the Gulf of Mexico, and portions of the Caribbean Sea. These activities will also occur at Navy pierside locations, Navy-contracted shipbuilder locations, port transit channels, and select bays, harbors and inshore waters, e.g., Chesapeake Bay (see Figure 1.2-1 and Section 2.1, Description of the Atlantic Fleet Training and Testing Study Area, for more detail on the geographic areas analyzed with regard to the Proposed Action).

1.4 Purpose and Need

The Navy and NMFS (as a cooperating agency) have coordinated from the outset and developed this document to meet each agency's distinct NEPA obligations and support the decision making of both agencies. The Navy's purpose for the Proposed Action is to ensure that the Navy meets its mission, which is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area in accordance with established Navy military readiness requirements. The sections that follow provide a description of the need for military readiness activities.

The Navy has requested authorization to take marine mammals incidental to conducting their testing and training activities in the Study Area by Level A and B harassment, serious injury, and/or mortality. Take under the MMPA is defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." For military readiness activities, harassment is defined as "(i) any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment] or (ii) any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered [Level B harassment]."

NMFS has issued proposed regulations and is considering issuance of subsequent Letters of Authorization under section 101(a)(5)(A) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 et seq.) that would govern the taking of marine mammals incidental to the Navy training and testing activities within the Study Area. The issuance of regulations and associated Letters of Authorization to the Navy is a major federal action requiring NMFS to analyze the effects of their issuance on the human environment pursuant to NEPA requirements and National Oceanic and Atmospheric Administration (NOAA) policies.

The purpose of issuing incidental take authorizations is to provide an exception to the take prohibition in the MMPA and to ensure that the action complies with the MMPA and implementing regulations. Incidental take authorizations may be issued as either: (1) regulations and associated Letters of Authorization under section 101(a)(5)(A) of the MMPA or (2) Incidental Harassment Authorizations under section 101(a)(5)(D) of the MMPA. An Incidental Harassment Authorizations can be issued only when there is no potential for serious injury or mortality or where any such potential can be negated through required mitigation measures. Because some of the activities under the Proposed Action may create a potential for lethal takes or takes that may result in serious injury that could lead to mortality, the Navy is requesting rulemaking and the issuance of Letters of Authorization for this action.

NMFS's purpose is to evaluate the Navy's Proposed Action pursuant to NMFS's authority under the MMPA, and to make a determination whether to issue incidental take regulations and Letters of Authorization, including any conditions needed to meet the statutory mandates of the MMPA. To authorize the incidental take of marine mammals, NMFS evaluates the best available scientific information to determine whether the take would have a negligible impact on the affected marine mammal species or stocks and an unmitigable impact on their availability for taking for subsistence uses (not relevant here for Navy's Proposed Action). NMFS must also prescribe permissible methods of taking, other "means of effecting the least practicable adverse impact" on the affected species or stocks and their habitat, and monitoring and reporting requirements. NMFS cannot issue an incidental take authorization unless it can make the required findings. The need for NMFS's action is to consider the impacts of the Navy's activities on marine mammals and meet NMFS' obligations under the MMPA. This Final EIS analyzes the environmental impacts associated with issuance of the requested authorization of the take of marine mammals incidental to the training and testing activities within the Study Area, to include a variety of mitigation measures that were considered during the MMPA authorization process. The analysis of mitigation measures considers benefits to species or stocks and their habitat, and analyzes the practicability and efficacy of each measure. This analysis of mitigation measures was used to support requirements pertaining to mitigation, monitoring, and reporting that would be specified in final MMPA regulations and subsequent Letters of Authorization.

1.4.1 Why the Navy Trains

Title 10 section 5062 of the U.S.C. provides: "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with integrated joint mobilization plans, for the expansion of the peacetime components of the Navy to meet the needs of war."

As described above, the Navy is statutorily mandated to protect U.S. national security by being ready, at all times, to effectively prosecute war and defend the nation by conducting operations at sea. The Navy is essential to protecting U.S. national interests, considering that 70 percent of the earth is covered in water, 80 percent of the planet's population lives within close proximity to coastal areas, and 90 percent of global commerce is conducted by sea. Naval forces must be ready for a variety of military operations to address the dynamic, social, political, economic, and environmental issues that occur in today's rapidly evolving world. Through its continuous presence on the world's oceans, the Navy can respond to a wide range of situations because, on any given day, over one-third of its ships, submarines, and aircraft are deployed overseas. Units must be able to respond promptly and effectively while forward deployed. This presence helps to dissuade aggression, which prevents conflict escalation, and provides the President with options to promptly address global contingencies. Before deploying, naval forces must train to develop a broad range of capabilities to respond to threats, from full-scale armed conflict in a variety of different geographic areas and environmental conditions to humanitarian assistance and disaster relief efforts. This also prepares Navy personnel to be proficient in operating and maintaining the equipment, weapons, and systems they will use to conduct their assigned missions. The training process provides personnel with an in-depth understanding of their individual limits and capabilities; the training process also helps the testing community improve new weapon systems' capabilities and effectiveness.

Modern weapons bring both unprecedented opportunities and challenges to the Navy. For example, precision (or smart) weapons help the Navy accomplish its mission with greater accuracy with far less collateral damage than in past conflicts; however, modern weapons are also very complex to use. Military personnel must train regularly with these weapons to understand the capabilities, limitations, and operations of the platform or system, as well as how to keep them operational under difficult conditions and without readily available technical or logistical assistance.

Modern military actions require teamwork among hundreds or thousands of people, across vast geographic areas, and the coordinated use of various equipment, ships, aircraft, and vehicles (e.g., unmanned aerial systems) to achieve success. Personnel increase in skill level by completing basic and specialized individual military training, then they advance to intermediate (e.g., unit-level training) and larger exercise training events, which culminate in advanced, integrated training composed of large groups of personnel and, in some instances, joint or combined exercises.[2]

Military readiness training must be as realistic as possible to provide the experiences vital to success and survival during military operations because simulated training, even in technologically advanced simulators, cannot duplicate the complexity faced by Sailors and Marines in the real world. While simulators and synthetic training are critical elements that provide early skill repetition and enhance teamwork, there is no substitute for live training in a realistic environment. Just as a pilot would not be ready to fly solo after simulator training, a Navy commander cannot allow military personnel to engage in military operations based merely on simulator training.

The large size of the range complex is essential to allow for realistic training scenarios that prepare Sailors and Marines for real-world operations. Only a large range complex offers the space necessary for operations such as the launch and recovery of aircraft or replenishment maneuvers which require a straight line course at a fixed speed for a sustained period of time. For example, in light wind conditions, to maintain a safe wind speed over the carrier's deck of 20 knots, flight operations taking 30 to 60 minutes would require traveling in a straight line over a distance of at least 10 to 20 nautical miles (NM) before any restrictive boundary was approached. Furthermore, multiple fixed wing aircraft landing on an aircraft carrier must be organized into a holding pattern, typically located 10 to 50 NM distance from the carrier, depending on several factors, including weather conditions, visibility, the number of aircraft waiting to land, and the condition of the aircraft (e.g., fuel remaining). To practice this maneuver safely away from civilian airspace, the carrier would need to be 20 to 50 NM away from any OPAREA boundary. In short, safe and effective Navy training often requires expansive operating areas due to a number of complex and interrelated factors.

The Navy also requires extensive areas of ocean to conduct its training in order to properly separate and coordinate different training events so that individual training events do not interfere with each other or with public and commercial vessels and aircraft. For example, hazardous activities such as gunnery or missile fire from a vessel in one training event would need to be conducted away from other training events. Additionally, large areas of ocean are required to ensure different training events can be conducted safely while minimizing the risks inherent in military training, such as aircraft flying too closely to one another or to commercial airways. Navy ships must also train to operate at long distances—often hundreds of miles—from each other while still maintaining a common picture of the "battlespace" so that individual Navy units can be coordinated to achieve a common objective. Separation of Navy units may also be required to ensure that participants of other exercises do not experience interference with sensors.

This need for expansive sea space is even more critical today as the Navy has a renewed emphasis on "sea control," which is the need to secure large areas of oceans from other highly capable naval forces. When the Cold War ended, the Navy emerged unchallenged and dominant. That dominance allowed the Navy to focus on projecting power ashore. The balance between sea control and power projection

[2] Large group exercises may include carrier strike groups, expeditionary strike groups, other U.S. services, and other nations.

tipped strongly in favor of the latter, and the Navy's surface force evolved accordingly. The Navy's proficiency in land-attack and maritime security operations reached new heights, while foundational skills in anti-submarine warfare and anti-surface warfare slowly began to erode. The emergence of more sophisticated capabilities by potential adversaries will require the Navy to operate farther from their coastline in times of conflict, and the modernization of navies able to challenge the U.S. Navy directly means that control of the seas can no longer be assumed. In response, the Navy is developing a model of "distributed lethality," which is intended to enhance the offensive power of individual surface ships. The concept of distributed lethality enables the goal of sea control where and when needed. It is achieved by increasing the offensive and defensive capability of individual warships, employing them in dispersed formations across a wide expanse of geography (e.g., hundreds of thousands of square miles). Extensive areas of ocean are required to effectively conduct distributed lethality training.

1.4.2 Optimized Fleet Response Plan

The Fleet Response Plan that the Navy operated under during Phase I and II emphasized constant readiness. The Fleet Response Plan identified the number of personnel and vessels that had to be ready to deploy on short notice (i.e., surge) in order to respond to rapidly evolving world events. For example, the Fleet Response Plan mandated that the Navy be able to deploy six aircraft carrier strike groups[3] within 3 months of a crisis and follow those with two more strike groups within 3 months after the first six deployed. Additionally, the Fleet Response Plan was based on a notional maintenance schedule and strike group deployments of 6 months in length and approximately 27 months between deployments. However, due to world events and the need for naval forces to be located overseas, Navy vessels were actually deployed for longer periods, resulting in longer maintenance periods. The Fleet Response Plan no longer represented actual fleet readiness preparation.

In December 2014 the Navy initiated the Optimized Fleet Response Plan, which reinforces the three tenets of "Warfighting First – Operate Forward – Be Ready" (U.S. Department of the Navy, 2014a). The Optimized Fleet Response Plan achieves this by better aligning manning distribution with operational requirements; optimizing maintenance and modernization plans; improving the overall quality of work and life balance for personnel; and ensuring that forces deploy with the right capabilities, properly trained and equipped to meet mission objectives. Like the previous plan, the Optimized Fleet Response Plan maintains a surge requirement by sustaining readiness of deployment-certified forces to enable three aircraft carrier strike groups in both the Atlantic and Pacific Oceans to respond to a national crisis. The Optimized Fleet Response Plan is now based on notional 7-month deployments and approximately 36 months between deployments. Following the Optimized Fleet Response Plan allows the Navy to respond timely to global events with the proper forces while maintaining a structured process that ensures continuous availability of trained, ready Navy forces.

The Optimized Fleet Response Plan outlines the training activities required to achieve a state of military readiness that will allow Navy personnel to execute operations as ordered by their commanders, to include responding to a conflict. The plan uses a building-block approach where initial basic training complements later phases of more complex training, with each phase building upon the skills obtained

[3] While strike groups could be configured differently, a typical aircraft carrier strike group would include an aircraft carrier, a guided missile cruiser, two guided missile destroyers, an attack submarine, and a supply ship.

in the previous phase. Specifically, training activities proceed in five phases: maintenance, basic, advanced, integrated, and sustainment, as depicted in Figure 1.4-1. The training events that occur in each of these phases are designed to prepare Sailors for the multitude of contingencies they may face, ranging from large strike group level activities such as defending against submarine or mine threats, conducting long-range bombing missions, putting Marines ashore in a hostile environment, to humanitarian responses for natural catastrophes such as earthquakes and hurricanes. To ensure Sailors and Marines can perform the variety of missions they could face, the training building blocks are designed to maximize their effectiveness at accomplishing the mission safely and professionally.

The Optimized Fleet Response Plan cycle starts at the beginning of the maintenance phase and ends upon the beginning of the next maintenance phase, as detailed below. Readiness increases throughout the cycle and culminates with the highest level of readiness at the end of the integrated or advanced phase.

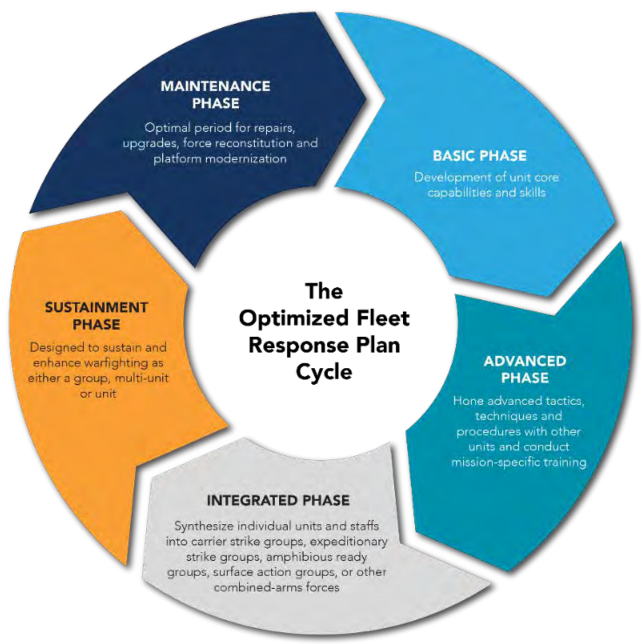

Figure 1.4-1: Optimized Fleet Response Plan

1.4.2.1 Maintenance Phase

The beginning of the maintenance phase signals the start of the Optimized Fleet Response Plan cycle. The goal of this phase is on-time completion of maintenance and modernization so that units are able to begin training and adhere to the Optimized Fleet Response Plan training schedule. All deployable Navy forces have a maintenance phase, which varies among different types of forces. The maintenance phase is critical to the success of the Optimized Fleet Response Plan since this represents the ideal time for major shipyard repairs, upgrades, and platform modernization. Also during this phase, Navy forces will complete required inspections, certifications, assist visits, and individual and team training to achieve required levels of personnel, equipment, supply, and ordnance readiness.

1.4.2.2 Basic Phase

The intent of the basic phase is to focus on the development of core capabilities and skills through the completion of basic-level training, inspections, certifications, and assessments. Achieving required levels of personnel, equipment, supply, and ordnance readiness is essential to success in subsequent Optimized Fleet Response Plan phases. Units that have completed all basic phase requirements are ready for more complex training and are capable of independent operations in support of homeland security, humanitarian assistance, and disaster relief missions.

The basic phase consists of training exercises performed by individual ships and aircraft and is mostly characterized as unit-level training. Unit-level training focuses on fundamental combat skills for a unit, such as an individual ship. Operating area and range support requirements for unit-level training are relatively modest compared to large-scale, major exercises. Coordinated unit-level exercises involve two or more units, such as ships, aircraft, or both and are also included in the basic phase. These exercises further refine the basic, fundamental skills while increasing difficulty by requiring coordination with other units.

Due to the repetition required in unit-level training, proximity of local range complexes to the locations where Sailors and Marines are stationed is important, as it reduces the amount of travel time and training costs during the basic phase of training. Access to local ranges also increases the time these Sailors and Marines can spend at home, with their families and communities before going on long deployments.

Ships and aircraft conducting basic phase training are likely operating in the same range complex or OPAREA where other units are conducting unrelated activities in the basic phase, integrated phase, or sustainment phase. Without sufficiently sized OPAREAs, this necessary, simultaneous training could not occur.

1.4.2.3 Advanced Phase

The purpose of the advanced phase is to build on unit warfighting capabilities through academic, synthetic, and live training in advanced training, tactics, and procedures in all mission areas within a challenging warfighting environment. This phase provides an opportunity to hone advanced training, tactics, and procedures with other units and conduct mission-specific training to meet mission requirements while maintaining proficiency attained in the basic phase. The advanced phase provides a sufficient block of time to complete required inspections, certifications, assessments, visits, and training. This phase includes attainment of acceptable unit warfighting proficiency in all required mission areas and completion of mission-specific training for identified mission sets. Upon completion of the advanced phase, most Navy forces will aggregate into a strike group, amphibious ready group, or other combined arms force and commence the integrated phase of training. Occasionally, forces will not conduct an integrated phase of training because, for example, they will be ordered to deploy independently (separate from a strike group or amphibious ready group). In those instances, these units will be certified to deploy following the advanced phase.

1.4.2.4 Integrated Phase

The goal of the integrated phase is to provide these units and staffs advanced warfare skills in a challenging, multidimensional, and realistic threat warfare environment. This phase allows members of a combined force to build on individual and unit-level skills and conduct multi-unit in-port and at-sea training, culminating in an assessment of their performance under high-end and high-stress realistic threat conditions. The integrated phase combines the units that have completed the advanced phase of training into strike groups (such as an Amphibious Ready Group). Strike groups are composed of multiple ships and aircraft operating together but covering many, sometimes thousands of square miles to simulate a real-world situation. For example, a strike group may be expected to operate in coordinated fashion in the entire Persian Gulf or Mediterranean Sea. Major exercises in this phase require access to large, relatively unrestricted areas of ocean and airspace, multiple targets, and unique range attributes (complex and varying oceanographic features, close proximity to naval bases, and land-based targets).

The integrated phase concludes with certification for deployment, meaning that the strike group has demonstrated the skills and proficiencies across the entire spectrum of warfare that may be needed during deployment.

1.4.2.5 Sustainment Phase

The sustainment phase includes all activities and training following certification for deployment until the next maintenance phase begins. The goal of the sustainment phase is to provide strike groups with training that allows forces to maintain their highest level of readiness and proficiency, as well as the ability to evaluate new and developing technologies, and evaluate and develop new tactics. The strike group needs to continue training after certification for deployment and upon return from deployment up until it enters the maintenance phase, to maintain its perishable skills.

Similar to the integrated phase, sustainment exercises require access to large, relatively unrestricted areas of ocean and airspace and unique range attributes to support the scenarios.

Ships and aircraft conducting sustainment phase training are likely operating in the same range complex or OPAREA where other units are conducting unrelated activities in the basic phase, advanced phase, integrated phase, or sustainment phase. Without sufficiently sized OPAREAs, this necessary, simultaneous training could not occur.

1.4.3 Why the Navy Tests

The Navy's research and acquisition community, including research funding organizations, laboratory facilities, and systems commands, have a mission to provide weapons, systems, and platforms for the men and women of the Navy that support their missions and give them a technological edge over the United States' adversaries. This community is at the forefront of researching, developing, testing, evaluating, acquiring, and delivering modern platforms, systems, and related equipment to meet Fleet capability and readiness requirements while providing the necessary high return on investment to the American taxpayer. The Navy's research funding organizations and laboratories concentrate primarily on the development of new science and technology and include the initial testing of concepts that are relevant to the Navy of the future. The results of these research efforts carry forward to the ship, aircraft, and weapon system products developed by systems commands, who support the full lifecycle of product and service delivery from research and development, to testing, acquisition, and deployment, to operations and logistics support, including maintenance, repair, and modernization of Navy platforms (e.g., ships, aircraft), weapon systems, and components. Testing begins at the research and development phase and continues through to the final certification of systems and hardware. For example, the building of a new ship would involve the development of all the software and hardware systems within the ship, the construction of the ship itself, and testing the ship's seaworthiness and operation of its systems. After delivery to the fleet, the testing community supports maintenance, provides updates to software and hardware systems, and may include training Sailors on the operation of the ship's systems.

The Navy's research, acquisition, and testing community includes the following:

- Naval Air Systems Command, which develops, acquires, delivers, and sustains naval aviation aircraft, weapons, and systems with proven capability and reliability to ensure Sailors and Marines achieve mission success.

- Naval Sea Systems Command, which develops, acquires, delivers, and maintains surface ships, submarines, unmanned vehicles, and weapon system platforms that provide the right capability to the Sailors and Marines.
- Office of Naval Research, which is a research funding organization that plans, fosters, encourages, and conducts a broad program of scientific research (at universities, industry, small business, etc.) that promotes future naval sea power, enhances national security, and meets the complex technological challenges of today's world. The Office of Naval Research is also a parent command for the Naval Research Laboratory, which operates as the Navy's corporate research laboratory and conducts a multidisciplinary program of scientific research.
- Space and Naval Warfare Systems Command, which provides the Sailor with knowledge superiority by developing, delivering, and maintaining effective, capable, and integrated command, control, communications, computer, intelligence, and surveillance systems.

The Navy's systems commands design, test, and build component, system, and platforms to address requirements identified by the fleet. The Navy's systems commands must test and evaluate the platform, system, or upgrade to validate whether it performs as expected and to determine whether it is operationally effective, suitable, survivable, and safe for its intended use by the fleet.

1.4.3.1 Types of Testing

Testing performed by the Navy's research and acquisition community can be categorized as scientific research testing, performance and specification testing, developmental testing, operational testing, fleet training support, follow-on test and evaluation, lot acceptance testing, or maintenance and repair testing. Fleet training events often offer the most suitable environment for testing a system because training events are designed to accurately replicate operational conditions. Testing, therefore, is often embedded in fleet training events such that distinguishing a testing event from a training event would be difficult for an observer, as the only difference could be the purpose for which the activity was being conducted. Categories of testing events include:

- **Scientific research testing.** Scientific research testing is required to evaluate emerging threats or technology enhancement before development of a new system. As an example, testing might occur on a current weapon system to determine if a newly developed technology would improve system accuracy or enhance safety to personnel. Additionally, scientific research involves the use of devices to measure the properties of the environment in which a system may operate. For example, acoustic propagation experiments are conducted in particular environments to see how far acoustic signals produced by current and future operational systems could travel. Other research activities involve the transmission of acoustic signals designed to convey information from one platform to another. This "acoustic communication" is also very dependent on environmental conditions and needs to be studied where a variety of these conditions occur.
- **Performance and specification testing.** Performance and specification tests are required prior to Navy acceptance of a new system or platform. These tests may be conducted on a Navy testing range, in a Navy range complex, or at pierside locations; these tests are sometimes done in conjunction with fleet training activities.
- **Developmental testing.** Developmental tests are conducted to assist in the design of a platform or system and to ensure that technical performance specifications have been met. For example,

a weapon system may be tested using prescribed settings (e.g., a specific run pattern) to ensure the full range of system parameters can be met.

- **Operational testing.** Operational tests are conducted by specialized Navy units to evaluate the platform or system under conditions as it would be used by the fleet during operations. For example, a weapons system may be tested without prearranged settings, such that the specialized unit conducting the test can make adjustments as necessary for the prevailing conditions.
- **Fleet training support.** Fleet training support is conducted when systems still under development may be integrated on ships or aircraft for testing, and new platforms and systems are transitioned to the fleet once they are ready for operational use. During this effort, the Navy's systems commands may provide training on the operation, maintenance, and repair of the system during developmental testing activities.
- **Follow-on test and evaluation.** A follow-on test and evaluation occurs when a platform receives a new system, after a significant upgrade to an existing system, or when the system failed to meet performance specifications during previous testing. Follow-on tests and evaluations ensure that the modified or new system meets performance requirements and does not conflict with existing platform systems and subsystems.
- **Lot acceptance testing.** Lot acceptance tests evaluate systems from the Department of Defense contractor's production line to ensure that the manufacturer is producing systems that conform to specifications and perform as designed. Lot acceptance testing serves as the Navy's quality control check of the system before it is delivered to the fleet.
- **Maintenance and repair testing.** Following periodic maintenance, overhaul, modernization, or repair of systems, testing of the systems may be required to assess performance. These testing activities may be conducted at sea, in shipyards, or at Navy piers.

Preparatory checks of a platform or system are often made during Navy repair and construction activities prior to actual testing to ensure the platform or system is operating properly before expending the often-considerable resources involved in conducting a full-scale test. For example, a surface combatant may conduct a functional check of its hull-mounted sonar system in a nearshore area before conducting a more rigorous test of the sonar system farther offshore.

1.4.3.2 Methods of Testing

The Navy uses a number of different testing methods, including computer simulation and analysis as well as at-sea testing, throughout the development of platforms and systems. Although computer simulation is a key component in the development of platforms and systems, it cannot provide information on how a platform or system will perform or whether it will be able to meet performance and other specification requirements in the environment in which it is intended to operate. Actual performance data are needed. For this reason, platforms and systems must undergo at-sea testing at some point in the development process. Thus, as with fleet training, the research and acquisition community requires access to large, relatively unrestricted ocean OPAREAs, multiple strike targets, and unique range attributes to support its testing requirements.

Navy platforms and systems must be tested and evaluated within the broadest range of operating conditions available (e.g., bathymetry, topography, geography, oceanographic conditions) because Navy personnel must be capable and confident to perform missions within the wide range of conditions that exist worldwide.

However, forecasting when technologies will be mature for testing is not easy. Programs and projects that have successfully completed the research and development stage and are determined mature enough to transition into an official, fully funded program have more defined test requirements. However, programs and projects are still subject to fiscal constraints and technical challenges that can often delay their development or even cancel continuation. Technical issues can require that systems or platforms undergo additional tests. Continued upgrades and maintenance of systems may occur on variable schedules due to availability, emergent requirements, or unforeseen system issues. Therefore, the types, amounts, and locations of testing activities may vary across different programs and projects in any given year. For all of these reasons, capturing the future testing requirements for platform, weapons, and system programs is challenging and reflects the system commands' best estimation based on historical and current best available information. To ensure comprehensive environmental impact analysis in this EIS/OEIS, the Navy assumes that all proposed testing projects will proceed as scheduled, with no unexpected delays.

1.5 Overview and Strategic Importance of Existing Range Complexes and Testing Ranges

The range complexes and testing ranges analyzed in this EIS/OEIS have each existed for many decades, some dating back to the 1940s. Range use and infrastructure have developed over time as military readiness requirements in support of modern warfare have evolved.

Proximity of the AFTT range complexes to naval homeports and air stations is strategically important to the Navy. Close access allows for efficient execution of military readiness activities including maintenance functions, as well as access to alternate airfields when necessary in order to provide for a margin of safety. Fuel is saved and equipment is exposed to less wear when ranges are near where the platforms are based. The proximity of training to homeports also ensures that Sailors and Marines do not spend unnecessary time away from their families during the training cycle. Additionally, the *Navy Personnel Tempo and Operating Tempo Program* requires the Navy to track and, where possible, limit the amount of time Sailors and Marines spend deployed from home (U.S. Department of the Navy, 2014b). Less time away from home is an important factor in military readiness, morale, and retention. The proximate availability of the AFTT range complexes is critical to Navy efforts in these areas.

The following range complexes and testing ranges are located in the AFTT Study Area and are described in further detail in Section 2.1 (Description of the Atlantic Fleet Training and Testing Study Area), as depicted in Figure 1.2-1:

- Northeast Range Complexes
- Naval Undersea Warfare Center Division, Newport Testing Range
- Virginia Capes Range Complex
- Navy Cherry Point Range Complex
- Jacksonville Range Complex
- Naval Surface Warfare Center Carderock Division, South Florida Ocean Measurement Facility Testing Range

- Key West Range Complex
- Gulf of Mexico Range Complex
- Naval Surface Warfare Center, Panama City Division Testing Range

1.6 THE ENVIRONMENTAL PLANNING PROCESS

This EIS/OEIS is designed to comply with the requirements of both NEPA and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions,* and support additional legal compliance requirements, as further described below. Since NEPA does not apply globally, President Carter issued Executive Order 12114 in 1979, furthering the purpose of NEPA by creating similar procedures for federal agency activities affecting the environment of the global commons outside U.S. jurisdiction. Thus, the Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders.

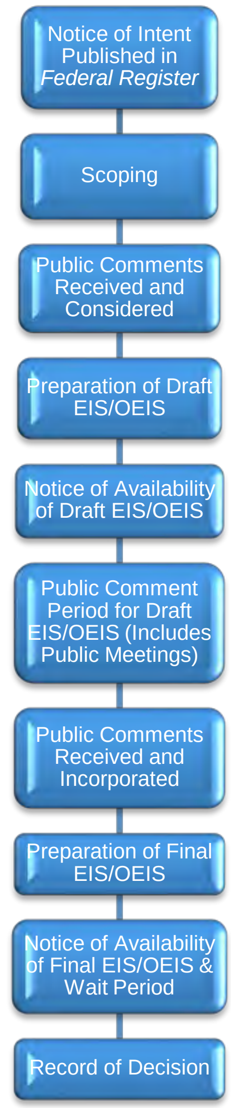

Figure 1.6-1: National Environmental Policy Act Process

1.6.1 NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

When developing an EIS, the first step in the NEPA process (Figure 1.6-1) is to prepare a Notice of Intent to develop an EIS. The Notice of Intent is published in the *Federal Register* and in local newspapers and provides an overview of the proposed action and the scope of the EIS. The Notice of Intent is also the first step in engaging the public, initiating the scoping process.

Scoping is an early and open process for developing the "scope" of issues to be addressed in an EIS and for identifying significant issues related to a proposed action. During this process, the public helps define and prioritize issues that will be analyzed in the EIS.

After the scoping process, a Draft EIS is prepared to assess potential impacts of the proposed action and alternatives on the environment. When completed, a Notice of Availability is published in the *Federal Register* and notices are placed in local or regional newspapers announcing the availability of the Draft EIS. The Draft EIS is circulated for public review and comment. Public meetings may also be scheduled to further inform the public and solicit their comments.

The Final EIS addresses all public comments received on the Draft EIS. Responses to public comments may include factual corrections, supplements or modifications to analysis, and inclusion of new information. Additionally, responses may explain why the comments do not warrant further agency response.

Finally, the decision-maker will issue a Record of Decision no earlier than 30 days after the Final EIS is made available to the public.

For a description of how the Navy complies with each of these requirements during the development of the AFTT EIS/OEIS, please see Chapter 8 (Public Involvement and Distribution).

1.6.2 Executive Order 12114

Executive Order 12114 of 1979, *Environmental Impacts Abroad of Major Federal Actions*, furthers the purpose of NEPA by directing federal agencies to provide for informed environmental decision making for major federal actions outside the United States and its territories. Presidential Proclamation 5928, issued December 27, 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 NM; however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 NM under NEPA (an EIS) and those effects occurring beyond 12 NM under the provisions of Executive Order 12114 (an OEIS).

1.6.3 Other Environmental Requirements Considered

The Navy must comply with all applicable federal environmental laws, regulations, and executive orders, including, but not limited to, those listed below. Further information can be found in Chapter 6 (Regulatory Considerations).

1.6.3.1 Federal Statutes

The following are federal statutes that are most relevant to the analysis of impacts in this EIS/OEIS.

1.6.3.1.1 Clean Air Act

The purpose of the Clean Air Act (42 U.S.C. sections 7401–7671q) is to protect public health and welfare by the control of criteria air pollution at its source and set forth primary and secondary National Ambient Air Quality Standards to establish criteria for states to attain, or maintain, these minimum standards. Non-criteria air pollutants that can affect human health are categorized as hazardous air pollutants under section 112 of the Clean Air Act. The U.S. Environmental Protection Agency identified 189 hazardous air pollutants such as benzene, perchloroethylene, and methylene chloride. Section 176(c)(1) of the Clean Air Act, commonly known as the General Conformity Rule, requires federal agencies to ensure that their actions conform to applicable state implementation plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants in non-attainment and maintenance areas for criteria pollutants and their precursors.

1.6.3.1.2 Clean Water Act

The Clean Water Act (33 U.S.C. sections 1251–1376) regulates discharges of pollutants in surface waters of the United States. The Uniform National Discharge Standards (40 Code of Federal Regulations [CFR] part 1700) govern discharges incidental to the normal operation of Navy ships at sea.

1.6.3.1.3 Coastal Zone Management Act

The Coastal Zone Management Act of 1972 (16 U.S.C. sections 1451–1464) encourages coastal states to be proactive in managing coastal zone uses and resources. The act established a voluntary coastal planning program and required participating states to submit a Coastal Management Plan to the National Oceanic and Atmospheric Administration for approval. Under the act, federal actions that have reasonably foreseeable effects on a coastal use or resource are required to be consistent, to the maximum extent practicable, with the enforceable policies of federally approved Coastal Management Plans. The Coastal Zone Management Act defines the coastal zone as extending offshore "to the outer limit of State title and ownership under the Submerged Lands Act" (i.e., 3 NM from the shoreline, 9 NM for the west coast of Florida, Texas, and Puerto Rico).

A consistency determination, a negative determination, or a *de minimis* exemption may be submitted for review of federal agency activities. A federal agency submits a consistency determination when it determines that its activity may have either a direct or an indirect effect on a state coastal use or resource. In accordance with 15 CFR section 930.39, the consistency determination will include a brief statement indicating whether the proposed activity will be undertaken in a manner consistent, to the maximum extent practicable, with the enforceable policies of the management program.

1.6.3.1.4 Endangered Species Act

The ESA of 1973 (16 U.S.C. sections 1531–1544) provides for the conservation of endangered and threatened species and the ecosystems on which they depend. The act defines an endangered species as a species in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service (USFWS) and NMFS jointly administer the ESA and are responsible for listing species as threatened or endangered and for designating critical habitat for listed species. The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a listed species, that agency is required to consult with the service (NMFS or USFWS) that has jurisdiction over the species (50 CFR section 402.14(a)). Consultation will conclude with preparation of a biological opinion that determines whether the federal agency action will jeopardize listed species or adversely modify or destroy critical habitat for formal consultation, or when the Services concur, in writing, that a proposed action "is not likely to adversely affect" listed species or designated critical habitat for informal consultation. An incidental take statement is also included in every biological opinion where take is anticipated. This incidental take statement allows the proposed action to occur without being subject to penalties under the ESA.

1.6.3.1.5 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. sections 1801–1882), enacted in 1976 and amended by the Sustainable Fisheries Act in 1996, mandates identification and conservation of essential fish habitat. Essential fish habitat is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity (i.e., full life cycle). These waters include aquatic areas and their associated physical, chemical, and biological properties used by fish, and may include areas historically used by fish. Substrate types include sediment, hard bottom, structures underlying the waters, and associated biological communities. Federal agencies are required to consult with NMFS and to prepare an essential fish habitat assessment if potential adverse effects on essential fish habitat are anticipated from their activities. Any federal agency action that is authorized, funded, undertaken, or proposed to be undertaken that may affect fisheries is subject to the Magnuson-Stevens Fishery Conservation and Management Act. In addition, federal agencies shall consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect any essential fish habitat identified under this act.

1.6.3.1.6 Marine Mammal Protection Act

The MMPA of 1972 established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals on the high seas by vessels or persons subject to U.S. jurisdiction. The term "take," as defined in section 3 (16 U.S.C. section 1362 (13)) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The MMPA directs the Secretary of Commerce, as delegated to NMFS, to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens or agencies who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigatable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). In issuing regulations authorizing the incidental taking, NMFS must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat and on the availability of the species or stock for subsistence uses (where relevant), and requirements pertaining to monitoring and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment, removed the "specified geographic area" requirement, and removed the small numbers provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government consistent with section 104(c)(3) (16 U.S.C. section 1374(c)(3)). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as codified at 16 U.S.C. section 703 Note. A "military readiness activity" is defined as "all training and operations of the Armed Forces that relate to combat" and the "adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." For military readiness activities, the relevant definition of harassment is any act that:

- injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment") or
- disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") (16 U.S.C. section 1362(18)(B)(i) and (ii)).

1.6.3.1.7 Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (16 U.S.C. sections 703–712) and the Migratory Bird Conservation Act (16 U.S.C. sections 715–715d, 715e, 715f–715r) of February 18, 1929, are the primary laws in the United States established to conserve migratory birds. The Migratory Bird Treaty Act prohibits the taking, killing, or possessing of migratory birds or the parts, nests, or eggs of such birds, unless permitted by regulation.

The 2003 National Defense Authorization Act provided interim authority to members of the Armed Forces to incidentally take migratory birds during approved military readiness activities without violating the Migratory Bird Treaty Act. The National Defense Authorization Act provided this interim authority to give the Secretary of the Interior time to exercise his/her authority under section 704(a) of the Migratory Bird Treaty Act to prescribe regulations authorizing such incidental take. The Secretary of the Interior delegated this task to the USFWS. On February 28, 2007, the USFWS issued a final military readiness rule (72 Federal Register 8931) authorizing members of the Armed Forces to incidentally take migratory birds during military readiness activities (U.S. Fish and Wildlife Service, 2007).

1.6.3.1.8 National Historic Preservation Act

The National Historic Preservation Act of 1966 (54 U.S.C. section 300101 et seq.) establishes preservation as a national policy and directs the federal government to provide leadership in preserving, restoring, and maintaining the historic and cultural environment. Section 106 of the National Historic Preservation Act requires federal agencies to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment. The National Historic Preservation Act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices to help protect each state's historical and archaeological resources. Section 110 of the National Historic Preservation Act requires federal agencies to assume responsibility for the preservation of historic properties owned or controlled by them and to locate, inventory, and nominate all properties that qualify for the National Register. Agencies shall exercise caution to assure that significant properties are not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate. The National Historic Preservation Act applies to cultural resources evaluated in this EIS/OEIS.

1.6.3.1.9 National Marine Sanctuaries Act

Under the Marine Protection, Research, and Sanctuaries Act of 1972 (also known as the National Marine Sanctuaries Act), the Secretary of Commerce may establish a national marine sanctuary for marine areas with special conservation, recreational, ecological, historical, cultural, archaeological, scientific, educational, or aesthetic qualities. Day-to-day management of national marine sanctuaries has been delegated by the Secretary of Commerce to the National Oceanic and Atmospheric Administration's Office of National Marine Sanctuaries. Once a sanctuary is designated, the Secretary of Commerce may authorize activities in the sanctuary only if they can be certified to be consistent with the National Marine Sanctuaries Act and can be carried out within the regulations for the sanctuary. Regulations exist for each sanctuary, and military activities may be authorized within those regulations. Additionally, the National Marine Sanctuaries Act requires federal agencies whose actions are "likely to destroy, cause the loss of, or injure a sanctuary resource" to consult with the program before taking the action. In these cases, the Office of National Marine Sanctuaries is required to recommend reasonable and prudent alternatives to protect sanctuary resources if the action is likely to destroy, cause the loss of, or injure a sanctuary resource. If the federal agency decides not to follow the recommendations, it must respond in writing to the Office of National Marine Sanctuaries.

1.6.3.2 Executive Orders

The following are Executive Orders that are most relevant to the analysis of impacts in this EIS/OEIS.

1.6.3.2.1 Executive Order 13834, *Efficient Federal Operations*

Executive Order 13834 (83 *Federal Register* 23771) was issued on May 17, 2018 and revoked Executive Order 13693. The goal of Executive Order 13834 is to prioritize actions that reduce waste, cut costs, enhance the resilience of Federal infrastructure and operations, and enable more effective accomplishment of an agency's mission.

1.6.3.2.2 Executive Order 13158, *Marine Protected Areas*

Executive Order 13158 (65 *Federal Register* 34909) was authorized in May 2000 to protect special natural and cultural resources by strengthening and expanding the nation's system of marine protected areas. The purpose of the order is to (1) strengthen the management, protection, and conservation of existing marine protected areas and establish new or expanded marine protected areas; (2) develop a scientifically based, comprehensive national system of marine protected areas representing diverse U.S. marine ecosystems and the nation's natural and cultural resources; and (3) avoid causing harm to marine protected areas through federally conducted, approved, or funded activities.

1.6.3.2.3 Executive Order 13840, *Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States*

On June 19, 2018, President Trump signed Executive Order 13840. The Executive Order is intended to advance the economic, security, and environmental interests of the United States through improved public access to marine data and information, efficient federal agency coordination on ocean-related matters, and engagement with marine industries, the science and technology community, and other ocean stakeholders, including Regional Ocean Partnerships. The Executive Order continues to require federal agencies to coordinate activities regarding ocean-related matters for effective management of the ocean as well as promote lawful use of the ocean by agencies, including the Armed forces. Navy continues to engage with regional and state ocean planning entities. This Executive Order revokes and replaces Executive Order 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*.

1.7 Scope and Content

In this EIS/OEIS, the Navy analyzed military readiness training and testing activities that could potentially impact human and natural resources, especially marine mammals, sea turtles, and other marine resources. The range of alternatives includes the No Action Alternative and two action alternatives. In this EIS/OEIS, the Navy analyzed direct, indirect, and cumulative impacts. The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS. The National Oceanic Atmospheric Administration's NMFS is a cooperating agency because the scope of the Proposed Action and alternatives involve activities that have the potential to impact protected resources under their jurisdiction and for which they have special expertise, including marine mammals, threatened and endangered species, essential fish habitat, and national marine sanctuaries. The National Oceanic Atmospheric Administration's authorities and special expertise is based on its statutory responsibilities under the MMPA, as amended (16 U.S.C. section 1361 et seq.), the ESA (16 U.S.C. section 1531 et seq.), the Magnuson-Stevens Fishery Conservation and Management Act and the National Marine Sanctuaries Act (16 U.S.C. sections 1431–1445c-1). In addition, NMFS, in accordance with 40 CFR sections 1506.3 and 1505.2, intends to adopt this EIS/OEIS and issue a separate Record of Decision associated with its decision to grant or deny the Navy's request for incidental take authorizations pursuant to section 101(a)(5)(A) of the MMPA.

In accordance with the Council on Environmental Quality Regulations, 40 CFR section 1505.2, the Navy will issue a Record of Decision that provides the rationale for choosing one of the alternatives.

1.8 Organization of this Environmental Impact Statement/Overseas Environmental Impact Statement

This EIS/OEIS is organized as follows:

- Chapter 1 describes the purpose of and need for the Proposed Action.
- Chapter 2 describes the Proposed Action, alternatives considered but eliminated in the EIS/OEIS, and alternatives to be carried forward for analysis in the EIS/OEIS.

- Chapter 3 describes the existing conditions of the affected environment and analyzes the potential impacts of the proposed training and testing activities for each alternative.
- Chapter 4 describes the analysis of cumulative impacts, which are the impacts of the Proposed Action when added to past, present, and reasonably foreseeable future actions.
- Chapter 5 describes the protective measures the Navy evaluated that could mitigate impacts to the environment.
- Chapter 6 describes considerations required by NEPA and describes how the Navy complies with other federal, state, and local plans, policies, and regulations.
- Chapter 7 includes a list of preparers of this EIS/OEIS.
- Chapter 8 includes a list of agencies, government officials, tribes, groups, and individuals on the distribution list for receipt of the Draft EIS/OEIS.
- Appendix A provides descriptions of the proposed Navy activities.
- Appendix B shows the relationship of stressors to the activities and to the environmental resources analyzed.
- Appendix C provides air quality emissions calculations and Record of Non-Applicability.
- Appendix D explains acoustic and explosive concepts.
- Appendix E provides estimates of marine mammals and sea turtle impacts from exposure to acoustic and explosive stressors under Navy training and testing activities.
- Appendix F presents military expended material and direct strike impact analysis.
- Appendix G presents Federal Register notices applicable to this project.
- Appendix H provides responses to public comments.
- Appendix I lists geographic information system data sources.
- Appendix J provides agency correspondence applicable to this project.

References

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

TABLE OF CONTENTS

List of Figures

List of Tables

2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The United States (U.S.) Department of the Navy (Navy) proposes to conduct training activities (hereinafter referred to as "training") and research, development, testing, and evaluation (hereinafter referred to as "testing") activities in the Atlantic Fleet Training and Testing (AFTT) Study Area, as represented in Figure 2.1-1. When discussed together, training and testing are also referred to as "military readiness activities." These military readiness activities include the use of active sonar and explosives within existing range complexes and testing ranges, in high seas areas located in the Atlantic Ocean along the eastern coast of North America, in portions of the Caribbean Sea and the Gulf of Mexico, at Navy pierside 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 generally consistent with those analyzed in the AFTT Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) completed in August 2013 and are representative of training and testing that the Navy has been conducting in the AFTT Study Area for decades.

In this chapter, the Navy builds upon the purpose and need to train and test by describing the Study Area and identifying the primary mission areas under which these military readiness activities are conducted. Each warfare community, e.g., aviation, surface, submarine, expeditionary, conducts activities that contribute to the success of a primary mission area (described in Section 2.2, Primary Mission Areas). Each primary mission area requires unique skills, sensors, weapons, and technologies to accomplish the mission. For example, under the anti-submarine warfare primary mission area, surface, submarine, and aviation warfare communities each utilize different skills, sensors, and weapons to locate, track, and eliminate submarine threats. The testing community contributes to the success of anti-submarine warfare by anticipating and identifying technologies and systems that respond to the needs of the warfare communities. As each warfare community develops its basic skills and integrates them into combined units and strike groups, the problems of communication, coordination and planning, movement, and positioning of naval forces and targeting/delivery of weapons become increasingly complex. This complexity creates a need for coordinated training and testing between the fleets and systems commands.

This chapter describes the training and testing activities, which compose the Proposed Action, necessary to meet military readiness requirements. These activities are then analyzed for their potential effects on the environment in the following chapters of this EIS/OEIS. For further details regarding specific training and testing activities, please see Appendix A (Navy Activity Descriptions). In accordance with the Marine Mammal Protection Act (MMPA), the Navy plans to submit to the National Marine Fisheries Service (NMFS) an application requesting authorization for the take of marine mammals incidental to training and testing activities described in this EIS/OEIS. NMFS's proposed action will be a direct outcome of responding to the Navy's request for an incidental take authorization pursuant to the MMPA.

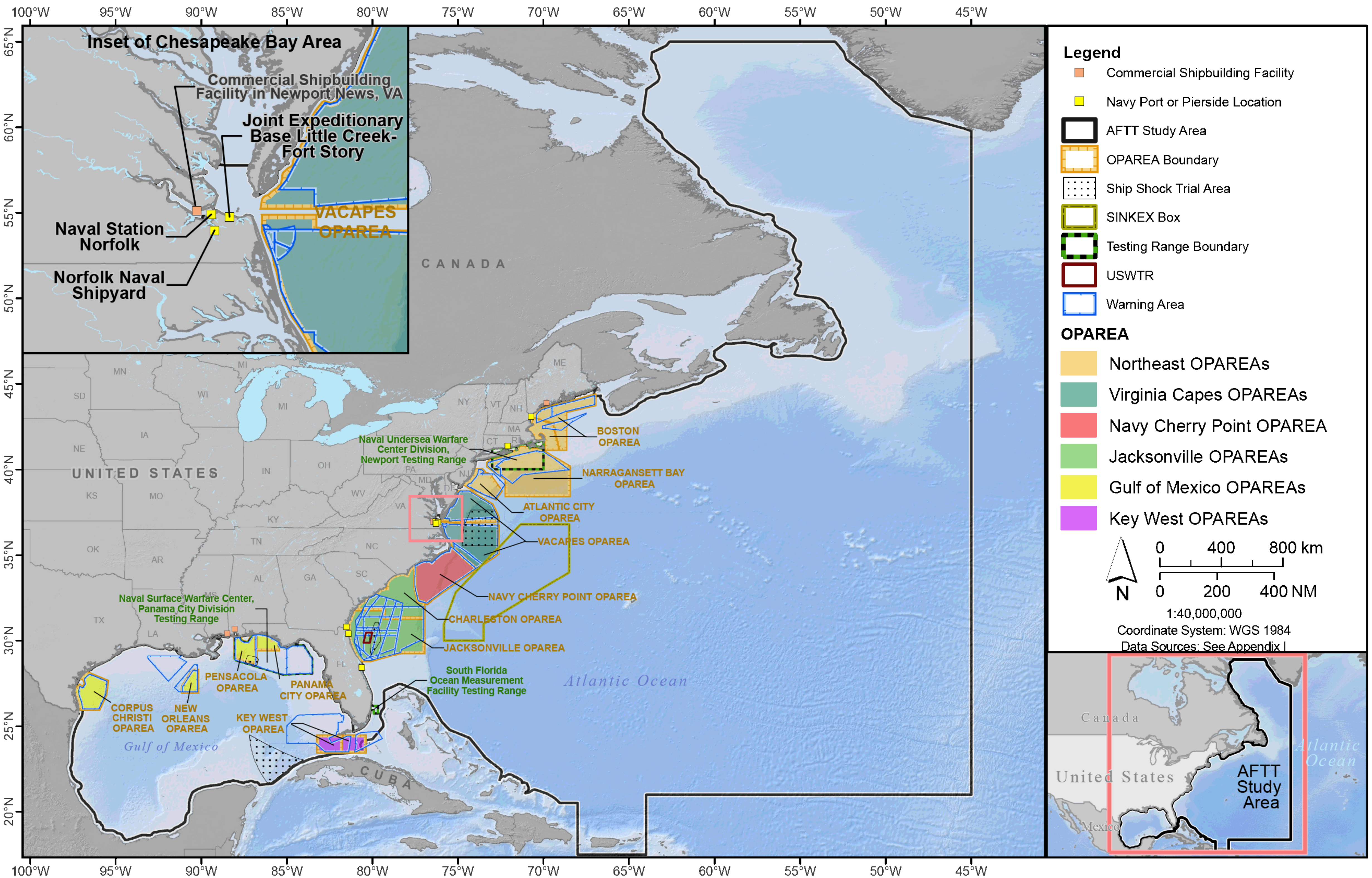
2.1 Description of the Atlantic Fleet Training and Testing Study Area

The AFTT EIS/OEIS Study Area 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 Study 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 Study Area also includes Navy pierside locations and port transit channels, bays, harbors, inshore waterways, and civilian ports where training and testing occurs (Section 2.1.10, Inshore Locations). The Study Area generally follows the Commander Task Force 80 area of operations, covering approximately 2.6 million square nautical miles (NM^2) of ocean area, and includes designated Navy range complexes and associated operating areas (OPAREAs) and special use airspace. While the AFTT Study Area itself is very large, it is important to note that the vast majority of Navy training and testing occurs in designated range complexes and testing ranges, as explained in Section 1.4 (Purpose and Need).

A Navy range complex consists of geographic areas that encompass a water component (above and below the surface) and airspace and may encompass a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occur. Range complexes include established OPAREAs 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:

- **Airspace**
  - **Special Use Airspace**. Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8). 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 nautical miles (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**. An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. OPAREAs include the following:
    - **Restricted Areas**. A restricted area is a defined water area 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 (Title 33 Code of Federal Regulations [CFR] part 334).

The Study Area includes only the at-sea components of the range complexes and testing ranges; land components associated with the range complexes and testing ranges are not included in the Study Area and no activities on these land areas are included as part of the Proposed Action. The Study Area also includes various bays, harbors, inshore waterways, and pierside locations within the boundaries of the range complexes; these are detailed in Section 2.1.10 (Inshore Locations).



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; USWTR: Undersea Warfare Training Range; VACAPES: Virginia Capes

Figure 2.1-1: Atlantic Fleet Training and Testing Study Area

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The Study Area is depicted in Figure 2.1-1. Regional maps contained in Figure 2.1-2 through Figure 2.1-4 show additional detail of the range complexes and testing ranges. The range complexes and testing ranges are described in the following sections.

2.1.1 Northeast Range Complexes

The Northeast Range Complexes include the Boston Range Complex, Narragansett Bay Range Complex, and Atlantic City Range Complex (Figure 2.1-2). These range complexes span 761 miles (mi.) 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.

2.1.1.1 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 18,000 ft. to unlimited altitudes. Six warning areas are located within the Northeast Range Complexes.

2.1.1.2 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.

2.1.2 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 2.1-2).

2.1.2.1 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.

2.1.2.2 Sea and Undersea Space

Three restricted areas are located within the Naval Undersea Warfare Center Division, Newport Testing Range:

- Coddington Cove Restricted Area (0.5 NM^2 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

2.1.3 Virginia Capes Range Complex

The Virginia Capes Range Complex spans 270 mi. along the coast from Delaware to North Carolina from the shoreline to 155 NM seaward (Figure 2.1-2). 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.

2.1.3.1 Airspace

The Virginia Capes Range Complex includes over 28,000 NM^2 of special use airspace. Flight altitudes range from the 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.

2.1.3.2 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.

2.1.4 Navy Cherry Point Range Complex

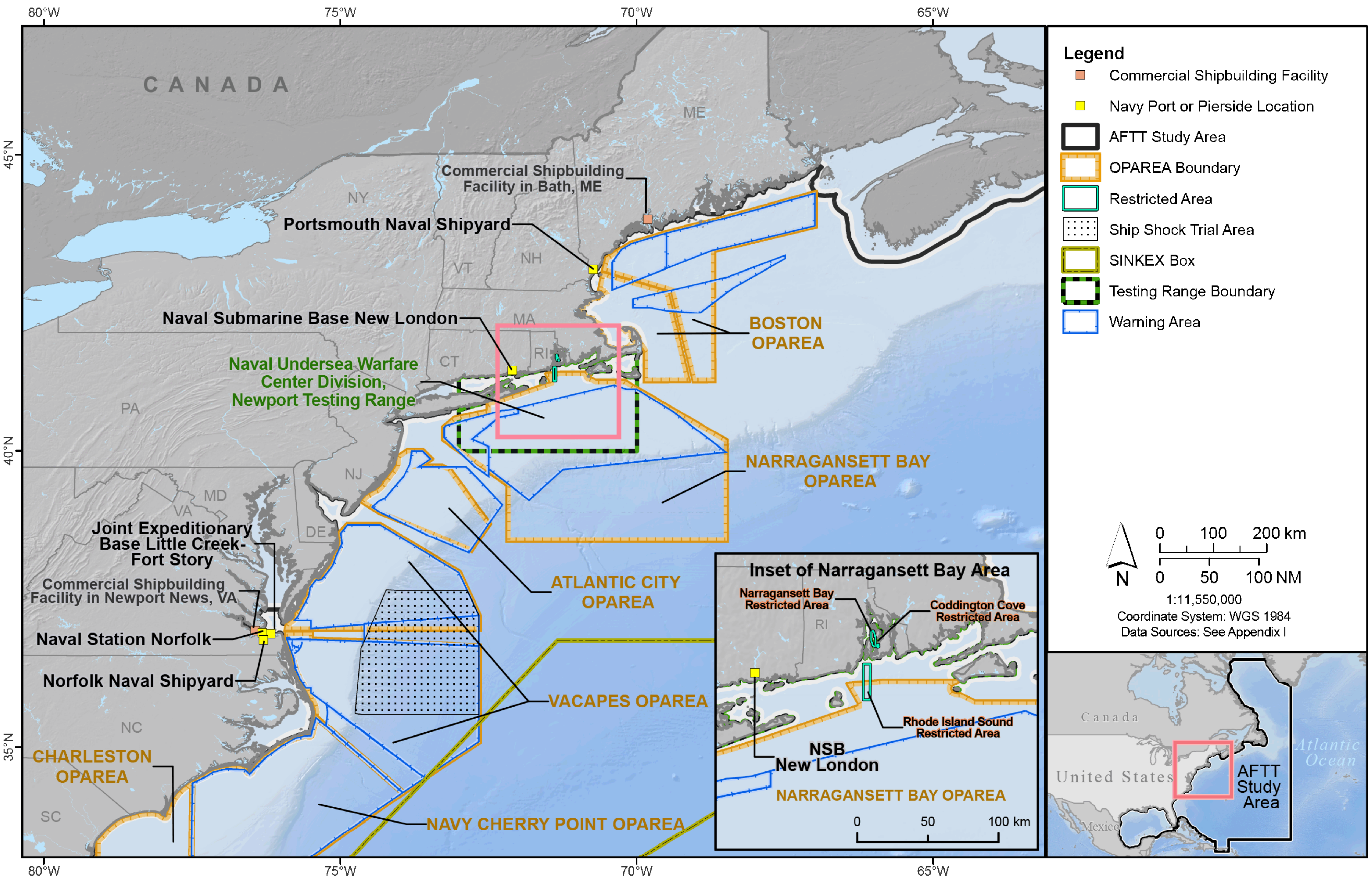
The Navy Cherry Point Range Complex, off the coast of North Carolina and South Carolina, encompasses the sea space from the shoreline to 120 NM seaward. The Navy Cherry Point Range Complex includes special use airspace with associated warning areas and surface and subsurface sea space of the Navy Cherry Point OPAREA (Figure 2.1-3). 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.

2.1.4.1 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.

2.1.4.2 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.



Notes: AFTT: Atlantic Fleet Training and Testing; NSB: Naval Submarine Base; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 2.1-2: Study Area, Northeast and Mid-Atlantic Region

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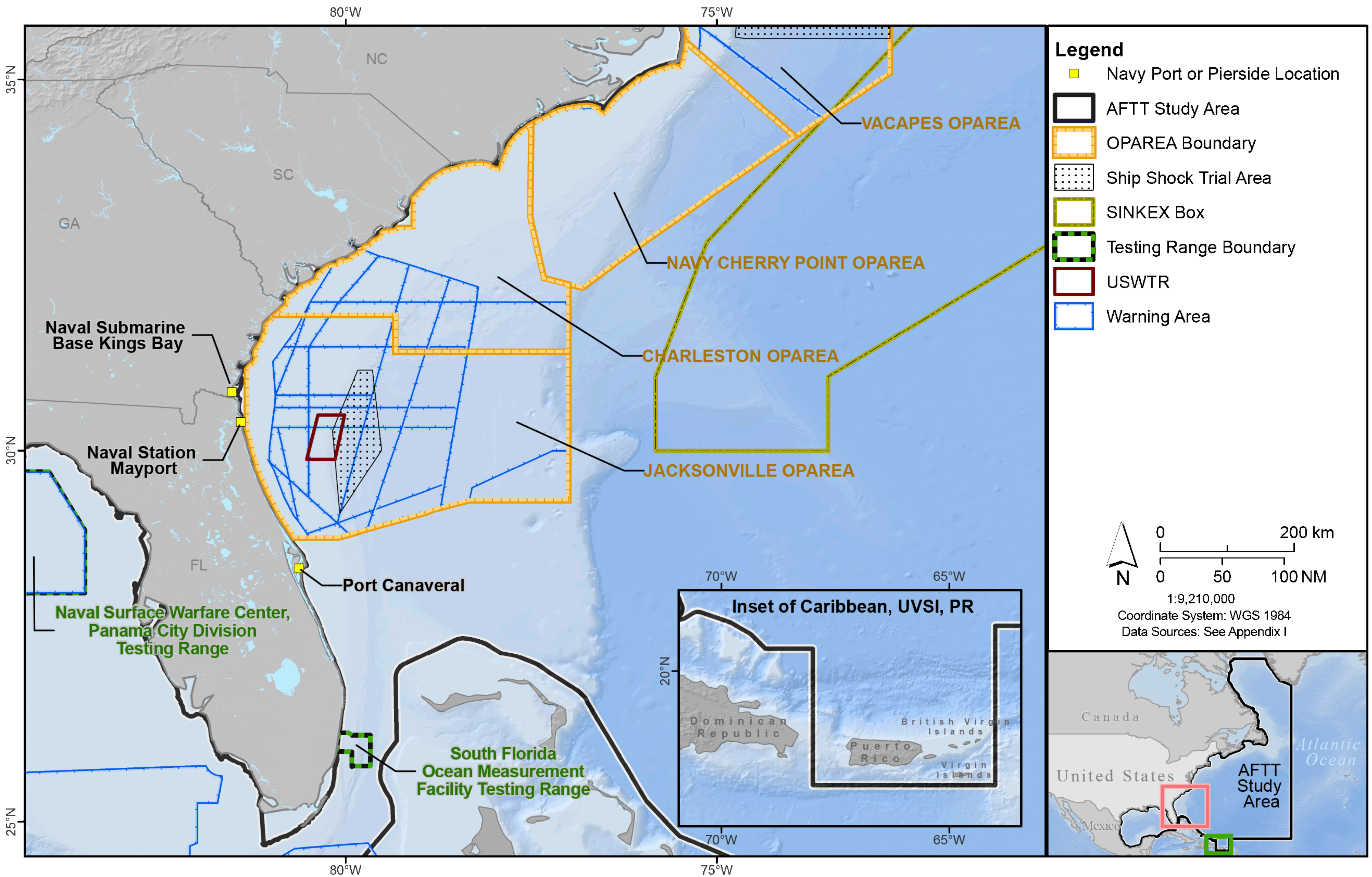

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; USWTR: Undersea Warfare Training Range; VACAPES: Virginia Capes

Figure 2.1-3: Study Area, Southeast Region and Caribbean Sea

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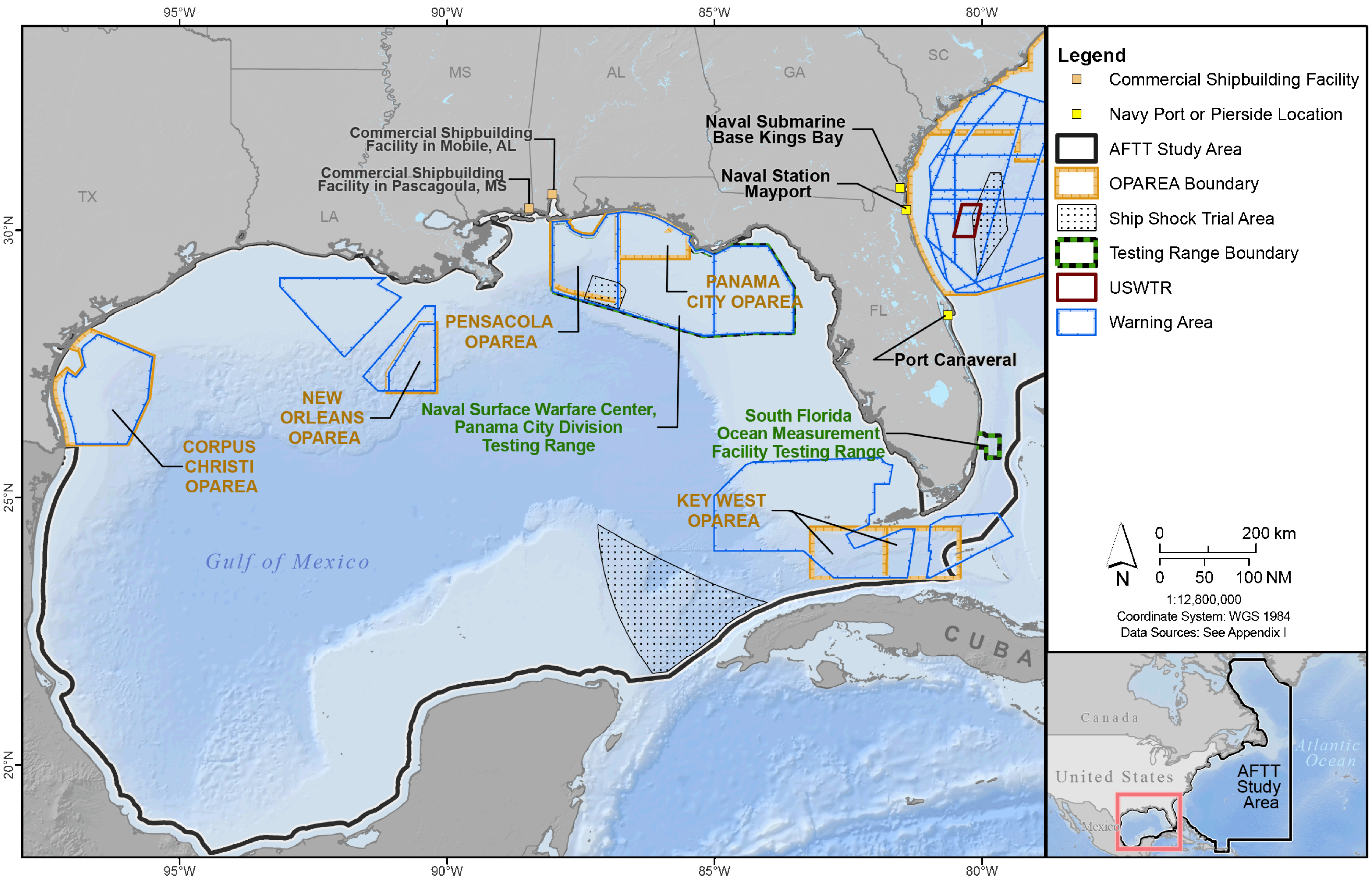

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; USWTR: Undersea Warfare Training Range

Figure 2.1-4: Study Area, Gulf of Mexico Region

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2.1.5 Jacksonville Range Complex

The Jacksonville Range Complex spans 520 mi. 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 is located within the Jacksonville Range Complex (Figure 2.1-3).

2.1.5.1 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.

2.1.5.2 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.

2.1.6 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, an offshore testing area in support of various Navy and non-Navy programs. The South Florida Ocean Measurement Facility Testing Range is located adjacent to the Port Everglades entrance channel in Fort Lauderdale, Florida (Figure 2.1-3). The test area at the South Florida Ocean Measurement Facility Testing Range includes an extensive cable field located within a restricted anchorage area and two designated submarine OPAREAs.

2.1.6.1 Airspace

The South Florida Ocean Measurement Facility Testing Range does not have associated special use airspace. The airspace adjacent to the South Florida Ocean Measurement Facility Testing Range is managed by the Fort Lauderdale International Airport. Air operations at the South Florida Ocean Measurement Facility Testing Range are coordinated with Fort Lauderdale International Airport by the air units involved in the testing events.

2.1.6.2 Sea and Undersea Space

The South Florida Ocean Measurement Facility Testing Range 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 South Florida Ocean Measurement Facility Testing Range cables run from offshore sensors to the shore facility and where several permanent measurement arrays are used for vessel signature acquisition.

2.1.7 Key West Range Complex

The Key West Range Complex lies off the southwestern coast of mainland 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 Key West Range Complex includes special use airspace with associated warning areas and surface and subsurface sea space of the Key West OPAREA (Figure 2.1-4).

2.1.7.1 Airspace

The Key West Range Complex 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 Key West Range Complex.

2.1.7.2 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.

2.1.8 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 2.1-4).

2.1.8.1 Airspace

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

2.1.8.2 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.

2.1.9 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 2.1-4).

2.1.9.1 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.

2.1.9.2 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.

2.1.10 Inshore Locations

Although within the boundaries of the range complexes detailed in Section 2.1.1 (Northeast Range Complex) through Section 2.1.9 (Gulf of Mexico Range Complex), various inshore locations, including piers, bays, and civilian ports, are identified in Appendix A (Navy Activity Descriptions) for various activities (Figure 2.2-1).

2.1.10.1 Pierside Locations

For purposes of this EIS/OEIS, 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 Study Area:

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

2.1.10.2 Bays, Harbors, and Inshore Waterways

Inshore waterways used for training and testing activities include:

- Narragansett Bay Range Complex/Naval Undersea Warfare Center Division, Newport Testing Range: Thames River, Narragansett Bay
- Virginia Capes Range Complex: James River and tributaries, Broad Bay, York River
- Jacksonville Range Complex: southeast Kings Bay, Cooper River, St. Johns River

- Gulf of Mexico Range Complex/Naval Surface Warfare Center, Panama City Division: St. Andrew Bay
- Key West Range Complex: Truman Harbor, Demolition Key

2.1.10.3 Civilian Ports

Civilian ports included for civilian port defense training events are listed in Section A.2.8.3 of Appendix A (Navy Activity Descriptions) and include:

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

2.2 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

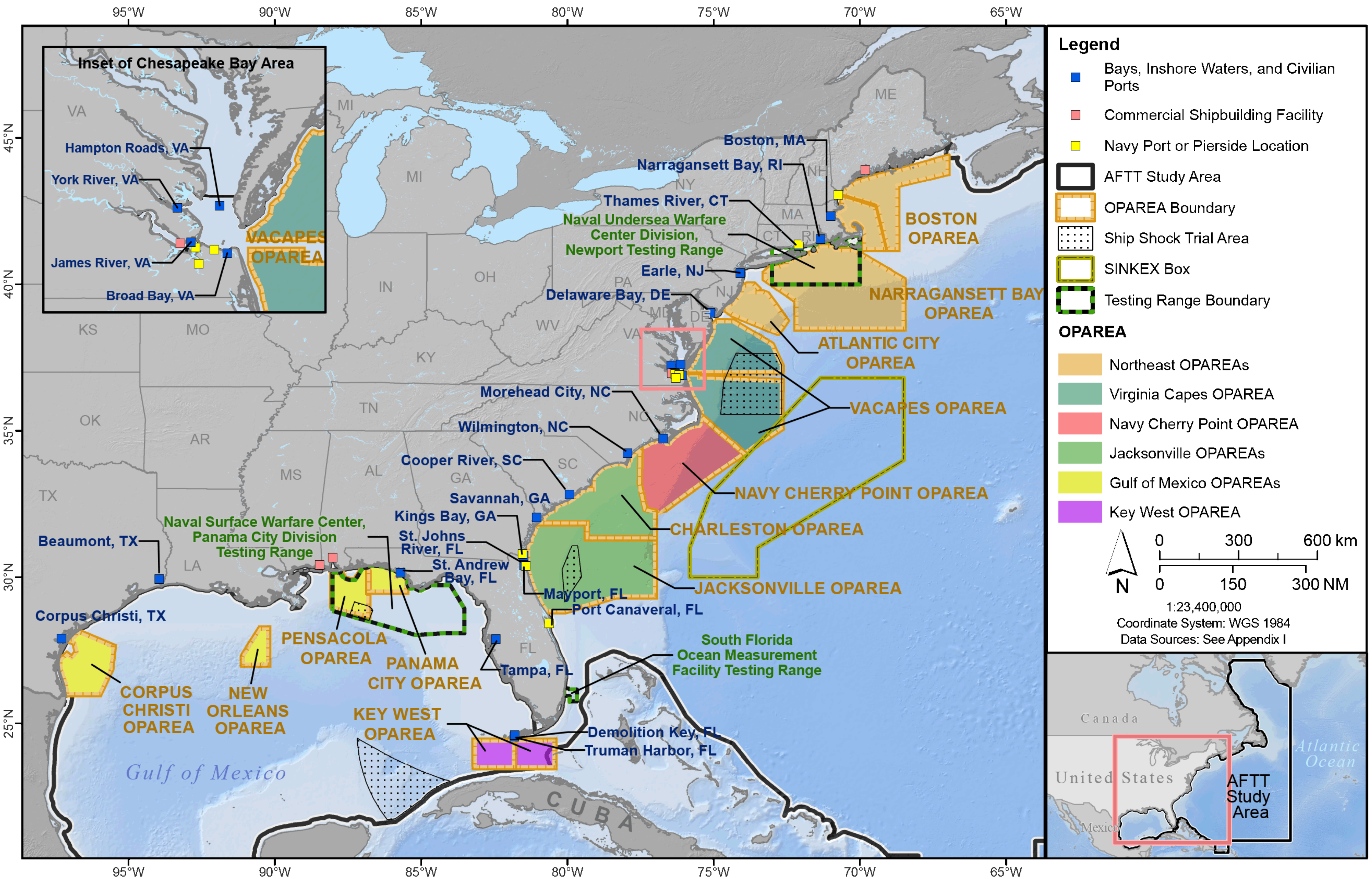
Most activities addressed in this EIS/OEIS are categorized under one of these primary mission areas; the testing community has three additional categories of activities for vessel evaluation, unmanned systems, and acoustic and oceanographic science and technology. Activities that do not fall within these areas are listed as "other activities." Each warfare community (surface, subsurface, aviation, and special 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 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).

2.2.1 Air Warfare

The mission of air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Air warfare provides U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

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.



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

Figure 2.2-1: Study Area, Inshore Locations

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2.2.2 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.

2.2.3 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.

2.2.4 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, see Appendix A, Navy Activity Descriptions, for a description of these devices) 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.

2.2.5 Expeditionary Warfare

The mission of expeditionary warfare is to provide security and surveillance in the littoral (at the shoreline), riparian (along a river), or 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.

2.2.6 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 involves 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 includes 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.

2.2.7 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 and subsurface 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.

2.3 Proposed Activities

The Navy has been conducting military readiness activities in the Study 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 influenced the frequency, duration, intensity, and location of required training and testing activities. This EIS/OEIS (Phase III) reflects the most up to date compilation of training and testing activities deemed necessary to accomplish military readiness requirements. The types and numbers of activities included in the Proposed Action accounts for fluctuations in training and testing in order to meet evolving or emergent military readiness requirements. For the purposes of this EIS/OEIS, the term “ship” is inclusive of surface ships and surfaced submarines. The term “vessel” is inclusive of ships and small boats (e.g., rigid-hull inflatable boats). In the following sections, the proposed training and testing activities are detailed.

2.3.1 Proposed Training Activities

A major training exercise comprises several “unit level” type exercises conducted by several units operating together while commanded and controlled by a single commander. These exercises typically employ an exercise scenario developed to train and evaluate the strike group in naval tactical tasks. 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 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. 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. These coordinated exercises are conducted under anti-submarine warfare. Three key factors used to identify and group the exercises are the scale of the exercise, duration of the exercise, and amount of hull-mounted sonar hours modeled/used for the exercise.

Table 2.3-1 provides the differences between major anti-submarine warfare training events and smaller integrated/coordinated anti-submarine exercises based on scale, duration, and sonar hours for the purposes of exercise reporting requirements.

The training activities proposed by the Navy are described in Table 2.3-2, which include the activity name and a short description of the activity. Appendix A (Navy Activity Descriptions) has more detailed descriptions of the activities.

Table 2.3-1: Major Anti-Submarine Warfare Training Exercises and Integrated/Coordinated Training

	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	JAX RC Navy Cherry Point RC VACAPES 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	JAX RC Navy Cherry Point RC VACAPES 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	JAX RC Navy Cherry Point RC VACAPES 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	JAX RC Navy Cherry Point RC VACAPES 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	JAX RC Navy Cherry Point RC VACAPES RC	ARG/MEU, Group Sail	Less than 50 hours

Notes: ASW: anti-submarine warfare; JAX: Jacksonville; RC: Range Complex; VACAPES: 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

Table 2.3-2: Proposed Training Activities

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 Exercise 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 rotary-wing aircraft 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.

Table 2.3-2: Proposed Training Activities (continued)

Activity Name	*Activity Description*
Missile Exercise Man-Portable Air Defense System	Personnel employ shoulder-fired surface-to-air missiles at air targets.
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 inland 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-wing 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-wing aircraft and helicopter aircrews deploy flares to disrupt threat infrared missile guidance systems.

Table 2.3-2: Proposed Training Activities (continued)

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 that 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-wing aircraft drop non-explosive mine shapes.
Mine Neutralization – Explosive Ordnance Disposal	Personnel 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 tiltrotor aircrews use small-caliber guns to engage surface targets.

Table 2.3-2: Proposed Training Activities (continued)

Activity Name	*Activity Description*
Gunnery Exercise Surface-to-Surface Boat Medium-Caliber	Small boat crews fire medium-caliber guns at surface targets.
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. Support pilings are driven into the sand and then later removed.
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.

Table 2.3-2: Proposed Training Activities (continued)

Activity Name	*Activity Description*
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.

2.3.2 Proposed 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 and give a technological edge over adversaries. The individual commands within the research and acquisition community included in this EIS/OEIS are Naval Air Systems Command, Naval Sea Systems Command, and the Office of Naval Research.

The Navy operates in an ever-changing strategic, tactical, financially constrained, and time-constrained environment. 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 may be designed based on advancements made by non-government researchers not yet published in the scientific literature. Similarly, future but yet unknown 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 the best that can be articulated in a long-term, comprehensive document, like this EIS/OEIS.

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.

2.3.2.1 Naval Air Systems Command Testing Activities

Naval Air Systems Command testing activities generally fall in the primary mission areas used by the fleets. 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.

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. However, 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. Training with systems and platforms delivered to the fleet within the timeframe of this document are analyzed in the training sections of this EIS/OEIS. Table 2.3-3 addresses Naval Air Systems Command's proposed testing activities.

Table 2.3-3: Naval Air Systems Command's Proposed Testing Activities

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.

Table 2.3-3: Naval Air Systems Command's Proposed Testing Activities (continued)

Activity Name	*Activity Description*
Electronic Systems Evaluation	Test that evaluates the effectiveness of electronic systems to control, deny, or monitor critical portions of the electromagnetic spectrum. In 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.

Table 2.3-3: Naval Air Systems Command's Proposed Testing Activities (continued)

Activity Name	*Activity Description*
High-Energy Laser Weapons Test	High-energy laser weapons tests evaluate the specifications, integration, and performance of an aircraft-mounted, high-energy laser used to disable small surface vessels.
Laser Targeting Test	Aircrews illuminate enemy targets with lasers.
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 hertz–100 kilohertz 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.

2.3.2.2 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. In this EIS/OEIS, pierside testing at Navy and contractor shipyards consists only of system testing.

Testing activities are conducted throughout the life of a Navy ship, from construction through deactivation from the fleet, to 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 test and evaluation programs for new technologies and systems; and testing on all ships and systems that have undergone overhaul or maintenance.

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 2.3-4 describes Naval Sea Systems Command's proposed testing activities.

Table 2.3-4: Naval Sea Systems Command's Proposed Testing Activities

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	Surface crews test large-caliber guns to defend against surface 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.
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.

Table 2.3-4: Naval Sea Systems Command's Proposed Testing Activities (continued)

Activity Name	*Activity Description*
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.

Table 2.3-4: Naval Sea Systems Command's Proposed Testing Activities (continued)

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.

2.3.2.3 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. The Office of Naval Research's mission is to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power and the preservation of national security. The Office of Naval Research manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test, and evaluation. The Office of Naval Research is also a parent organization for the Naval Research Laboratory, which operates as the Navy's corporate research laboratory and conducts a broad multidisciplinary program of scientific research and advanced technological development. Testing conducted by the Office of Naval Research in the AFTT Study Area includes acoustic and oceanographic research, large displacement unmanned underwater vehicle (innovative naval prototype) research, and emerging mine countermeasure technology research. Table 2.3-5 describes the Office of Naval Research's proposed testing activities.

Table 2.3-5: Office of Naval Research Proposed Testing Activities

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.

2.3.3 Standard Operating Procedures

For training and testing to be effective, units must be able to safely use their sensors and weapon systems as they are intended to be used in military missions and combat operations and to their optimum capabilities. Standard operating procedures applicable to training and testing have been developed through years of experience, and their primary purpose is to provide for safety (including public health and safety) and mission success. In many cases, there are benefits to environmental and cultural resources (some of which have high socioeconomic value in the Study Area) resulting from standard operating procedures. Navy standard operating procedures are published or broadcast via numerous naval instructions and manuals, including but not limited to:

- Ship, submarine, and aircraft safety manuals
- Ship, submarine, and aircraft standard operating manuals
- Fleet Area Control and Surveillance Facility range operating instructions
- Fleet exercise publications and instructions
- Naval Sea Systems Command test range safety and standard operating instructions
- Navy instrumented range operating procedures
- Naval shipyard sea trial agendas
- Research, development, test, and evaluation plans
- Naval gunfire safety instructions
- Navy planned maintenance system instructions and requirements
- Federal Aviation Administration regulations
- International Regulations for Preventing Collisions at Sea

Because they are essential to safety and mission success, standard operating procedures are part of the Proposed Action and are considered in the Chapter 3 (Affected Environment and Environmental Consequences) environmental analysis for applicable resources. Standard operating procedures that provide a benefit to public health and safety, environmental resources, or cultural resources are discussed in the sections below and included in Appendix A (Navy Activity Descriptions).

Standard operating procedures (which are implemented for the purpose of safety and mission success) are different from mitigation measures (which are implemented for the purpose of avoiding or reducing potential impacts on environmental and cultural resources). A brief introduction to the activities, stressor categories, and geographic areas for which the Navy will implement mitigation is provided in Section 2.3.4 (Mitigation Measures). A full discussion of mitigation measures is presented in Chapter 5 (Mitigation).

2.3.3.1 Sea Space and Airspace Deconfliction

The Navy schedules training and testing activities to minimize conflicts with the use of sea space and airspace within ranges and throughout the Study Area to ensure the safety of military personnel, the public, commercial aircraft, commercial and recreational vessels, and military assets. The Navy deconflicts its own use of sea space and airspace to allow for the necessary separation of multiple Navy units to prevent interference with equipment sensors and avoid interaction with established commercial air traffic routes and commercial shipping lanes. These standard operating procedures benefit public health and safety (including persons participating in activities that have socioeconomic value, such as recreational or commercial fishing) through a reduction in the potential for interactions with training and testing activities.

2.3.3.2 Vessel Safety

Navy vessels are required to operate in accordance with applicable navigation rules, including Inland Navigation Rules (33 CFR 83) and International Regulations for Preventing Collisions at Sea (72 COLREGS), which were formalized in the Convention on the International Regulations for Preventing

Collisions at Sea, 1972. Applicable navigation requirements include, but are not limited to, Rule 5 (Lookouts) and Rule 6 (Safe Speed). These rules require that vessels at all times proceed at a safe speed so proper and effective action can be taken to avoid collision and so vessels can be stopped within a distance appropriate to the prevailing circumstances and conditions. Navy ships transit at speeds that are optimal for fuel conservation, maintaining ship schedules, and meeting mission requirements. Vessel captains use the totality of the circumstances to ensure the vessel is traveling at appropriate speeds in accordance with navigation rules. Depending on the circumstances, this may involve adjusting speeds during periods of reduced visibility or in certain locations. With limited exceptions (e.g., amphibious vessels operating in designated locations), Navy vessels avoid contact with the seafloor as a standard collision avoidance procedure to prevent damage to vessels. Information on vessels that will be used under the Proposed Action is provided in Section 3.0.3.3.4.1 (Vessels and In-Water Devices).

Ships operated by or for the Navy have personnel assigned to stand watch at all times, day and night, when moving through the water (underway) for safety of navigation, collision avoidance, range clearance, and man-overboard precautions. Watch personnel include officers, enlisted men and women, and civilians operating in similar capacities. To qualify to stand watch, personnel undertake extensive training that includes, but is not limited to, on-the-job instruction and a formal Personal Qualification Standard program (or equivalent program for civilians) to certify that they have demonstrated all necessary skills. While on watch, personnel employ visual search and reporting procedures in accordance with the U.S. Navy Lookout Training Handbook or civilian equivalent. Watch personnel are responsible for using correct scanning procedures while monitoring an assigned sector; estimating relative bearing, range, position angle, and target angle of sighted objects; and rapidly sending accurate reports of all visual information to the bridge and combat information center. After sunset and prior to sunrise, watch personnel employ night visual search techniques, which could include the use of night vision devices.

Watch personnel monitor their assigned sectors for any indication of danger to the ship and the personnel on board, such as a floating or partially submerged object or piece of debris, periscope, surfaced submarine, wisp of smoke, flash of light, or surface disturbance. As a standard collision avoidance procedure, watch personnel also monitor for marine mammals that have the potential to be in the direct path of the ship. Watch personnel duties may be performed in conjunction with other tasks or job responsibilities, such as navigating the ship or supervising other personnel. Watch personnel are not normally posted while ships are moored to a pier. When anchored or moored to a buoy, a watch team is still maintained but with fewer personnel than when underway.

The standard operating procedures for vessel safety benefit public health and safety, marine mammals, and seafloor resources through a reduction in the potential for vessel strikes.

2.3.3.3 Aircraft Safety

Pilots of Navy aircraft make every attempt to avoid large flocks of birds and bats to reduce the safety risk involved with a potential strike. Since 2011, the Navy has required that all Navy flying units report all bird and bat strikes through the Web-Enabled Safety System Aviation Mishap and Hazard Reporting System. The standard operating procedures for aircraft safety benefit birds and bats through a reduction in the potential for aircraft strike.

2.3.3.4 High-Energy Laser Safety

The Navy operates laser systems approved for fielding by the Laser Safety Review Board or service equivalent. Only properly trained and authorized personnel operate high-energy lasers within designated OPAREAs and ranges. OPAREAs and ranges where lasers are used are required to have a Laser Range Safety Certification Report that is updated every 3 years. Prior to commencing activities involving high-energy lasers, the operator performs a search of the intended impact location to ensure that the area is clear of unauthorized persons. These standard operating procedures benefit public health and safety through a reduction in the potential for interaction with high-energy lasers.

2.3.3.5 Weapons Firing Safety

A Notice to Mariners is issued in advance of gunnery activities to alert the public to stay clear of the area, except for small-caliber crew-served weapons training when the immediate area around the firing ship is cleared visually. Locations where explosive bombing activities occur often have a standing Notice to Mariners. Notices to Mariners are issued in advance of explosive bombing activities conducted in locations that do not already have a standing notice. Additional information on Notices to Mariners is provided in Section 3.12.2.1.1 (Sea Space).

Most weapons firing activities that involve the use of explosive munitions are conducted during daylight hours. All missile and rocket firing activities are carefully planned in advance and conducted under strict procedures that place the ultimate responsibility for range safety on the Officer Conducting the Exercise or civilian equivalent. The weapons firing hazard range must be clear of non-participating vessels and aircraft before firing activities commence. The size of the firing hazard range is based on the farthest firing range capability of the weapon being used. All weapons firing stops when the Range Safety Officer receives a cease-fire order or when the line of fire could endanger non-participating vessels or aircraft. 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 is not possible. The two exceptions to this requirement are: (1) when operating in the open ocean, clearance for non-participating aircraft and vessels 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. These standard operating procedures benefit public health and safety, and marine mammals and sea turtles (by increasing the effectiveness of visual observations for mitigation in daylight hours), through a reduction in the potential for interaction with explosive weapons firing activities.

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. Recovery of these items helps minimize materials that remain, which could potentially alert enemy forces to the presence of U.S. Navy assets during military missions and combat operations. This standard operating procedure benefits biological resources (e.g., marine mammals, sea turtles, fish) through a reduction in the potential for physical disturbance and strike, entanglement, and ingestion of applicable targets and any associated decelerators/parachutes. Additional information about military expended materials (including which are recoverable) is presented in Section 3.0.3.3.4.2 (Military Expended Materials) and Appendix F (Military Expended Material and Direct Strike Impact Analysis).

2.3.3.6 Target Deployment and Retrieval Safety

The deployment and retrieval of targets is dependent upon environmental conditions. The Beaufort sea state scale is a standardized measurement of the weather conditions, based primarily on wind speed. The scale is divided into levels from 0 to 12, with 12 indicating the most severe weather conditions (e.g., hurricane force winds). At Beaufort sea state number 4, wave heights typically range from 3.5 to 5 ft.

Firing exercises involving the deployment and retrieval of targets (e.g., integrated maritime portable acoustic scoring and simulation systems) from small boats are typically conducted in daylight hours in Beaufort sea state number 4 conditions or better to ensure safe operating conditions during target deployment and recovery. These standard operating procedures benefit public health and safety, and marine mammals and sea turtles (by increasing the effectiveness of visual observations for mitigation), through a reduction in the potential for interaction with the weapons firing activities associated with the use of applicable deployed targets.

2.3.3.7 Swimmer Defense Activity Safety

A Notice to Mariners is issued in advance of all swimmer defense activities. Additional information on Notices to Mariners is provided in Section 3.12.2.1.1 (Sea Space). A daily in situ calibration of sound source levels is used to establish a clearance area to the 145 decibels referenced to 1 micropascal (dB re 1 μPa) sound pressure level threshold for non-participant safety. A hydrophone is used during the calibration sequences in order to confirm the clearance area. Small boats patrol the 145 dB re 1 μPa sound pressure level area during all activities. Boat crews are equipped with binoculars and remain vigilant for non-participant boats, swimmers, snorkelers, divers, and dive flags. If a non-participating swimmer, snorkeler, or diver is observed entering into the area of the swimmer defense system, the power levels of the defense system are reduced. An additional 100-yard buffer is applied to the initial sighting location of the non-participant as an additional precaution, and this buffer area is used to determine if the non-participant is within the 145 dB re 1 μPa zone. If the area cannot be maintained free of non-participating swimmers, snorkelers, and divers, the activity will cease until the non-participant has moved outside the area. These standard operating procedures benefit public health and safety (including persons participating in activities that have socioeconomic value, such as recreational diving) through a reduction in the potential for interaction with swimmer defense activities.

2.3.3.8 Pierside Testing Safety

The *U.S. Navy Dive Manual* (U.S. Department of the Navy, 2011) prescribes safe distances for divers from active sonar sources and in-water explosions. Safety distances for the use of electromagnetic energy are specified in DoD Instruction 6055.11 (U.S. Department of Defense, 2009) and Military Standard 464A (U.S. Department of Defense, 2002). These distances are used as the standard safety buffers for in-water energy to protect Navy divers. If an unauthorized person is detected within the exercise area, the activity will be temporarily halted until the area is again cleared and secured. These standard operating procedures benefit public health and safety (including persons participating in activities that have socioeconomic value, such as commercial or recreational diving) through a reduction in the potential for interaction with pierside testing activities.

2.3.3.9 Underwater Detonation Safety

Underwater detonation training takes place in designated areas that are located away from popular recreational dive sites, primarily for human safety. Recreational dive sites oftentimes include shallow-water coral reefs, artificial reefs, and shipwrecks. If an unauthorized person (e.g., a recreational diver) is detected within the exercise area, the activity will be temporarily halted until the area is cleared and secured. Notices to Mariners are issued when the events are scheduled to alert the public to stay clear of the area. Additional information on Notices to Mariners is provided in Section 3.12.2.1.1 (Sea Space). These standard operating procedures benefit public health and safety, environmental resources (e.g., shallow-water coral reefs, artificial reefs, and the biological resources that inhabit, shelter in, or feed among them), and cultural resources (e.g., shipwrecks) through a reduction in the potential for interaction with underwater detonation activities.

2.3.3.10 Sonic Booms

As a general policy, aircraft do not intentionally generate sonic booms below 30,000 ft. of altitude unless over water and more than 30 mi. from inhabited land areas or islands. The Navy may authorize deviations from this policy for tactical missions; phases of formal training syllabus flights; or research, test, and operational suitability test flights. The standard operating procedures for sonic booms benefit public health and safety through a reduction in the potential for exposure to sonic booms.

2.3.3.11 Unmanned Aerial System, Surface Vehicle, and Underwater Vehicle Safety

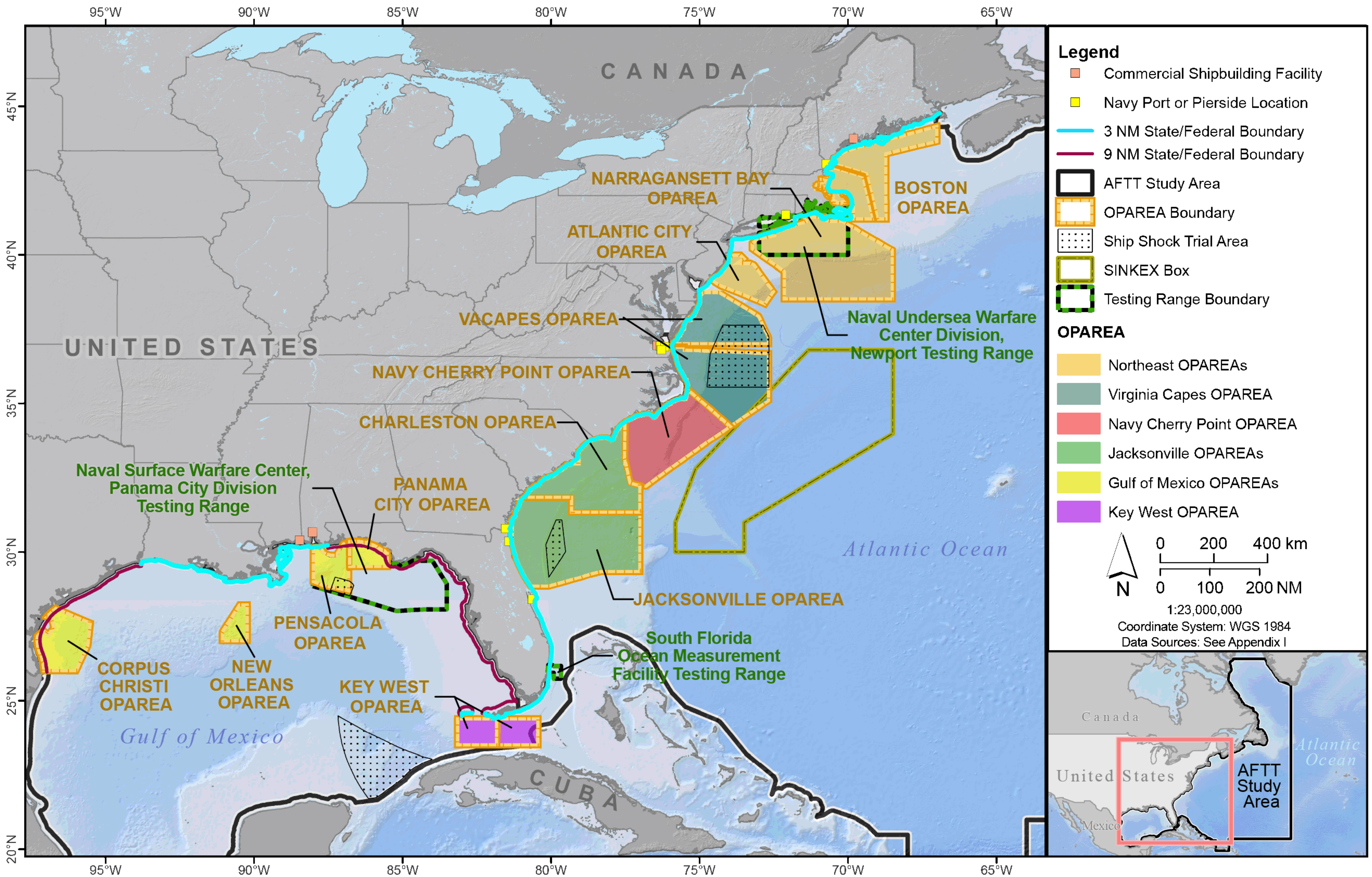
For activities involving unmanned aerial systems, surface vehicles, or underwater vehicles, the Navy evaluates the need to publish a Notice to Airmen or Notice to Mariners based on the scale, location, and timing of the activity. When necessary, Notices to Airmen and Notices to Mariners are issued to alert the public to stay clear of the area. Additional information is provided on Notices to Mariners in Section 3.12.2.1.1 (Sea Space) and Notices to Airmen in Section 3.12.2.1.2 (Airspace). Unmanned aerial systems are operated in accordance with Federal Aviation Administration air traffic organization policy as specified in Office of the Chief of Naval Operations Instructions 3710, 3750, and 4790. These standard operating procedures benefit public health and safety through a reduction in the potential for interaction with these unmanned systems and vehicles.

2.3.3.12 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 benefits marine mammals, sea turtles, and vegetation through a reduction in the potential for physical disturbance and strike by a towed in-water device. Concentrations of floating vegetation can be indicators of potential marine mammal or sea turtle presence because marine mammals and sea turtles have been known to seek shelter in, feed on, or feed among them. For example, young sea turtles have been known to hide from predators and eat the algae associated with floating concentrations of *Sargassum.*

2.3.3.13 Ship Shock Trial Safety

The Navy may conduct ship shock trials in three designated areas within the Study Area (Figure 2.3-1). Notices to Mariners and Notices to Airmen are issued in advance of all ship shock trial activities to alert the public to stay clear of the area. Additional information is provided on Notices to Mariners in Section 3.12.2.1.1 (Sea Space) and Notices to Airmen in Section 3.12.2.1.2 (Airspace). An area with a 5-NM radius is established around the detonation point to exclude all non-participating vessels and aircraft. This area will be established 5 to 6 hours prior to each detonation and may continue post-detonation for a total exclusionary time of up to 12 hours. This area is an electronic emissions control zone that virtually eliminates the possibility of an inadvertent detonation caused by a radio or radar-induced electrical current in the explosive firing circuit. This area also provides for safe maneuvering of the explosive-laden operations vessel. Since the ship being tested and the operations vessel are not stationary during the ship shock trial activities, the associated area around the detonation point moves with the vessel. Ship shock trial activities are immediately stopped when a non-participating vessel or aircraft enters or is detected within the 5-NM clearance area. If a non-participating vessel or aircraft is detected within a 10-NM radius of ship shock trial activities, the



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Ship Sinking Exercises; VACAPES: Virginia Capes

Figure 2.3-1: Coastal Zones and Designated Ship Shock Trial and Sinking Exercise Areas with Standard Operating Procedures

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non-participant is warned to alter course. This is necessary for operational security and to allow large vessels sufficient time to change course to avoid entering the clearance area. These security measures continue until the area is clear of non-participating vessels and aircraft.

In the unlikely event a charge fails to explode, additional attempts to detonate the charge will be made. If detonation fails, the explosive will be recovered and disarmed. If the explosive cannot be detonated or disarmed, to safeguard human life, the explosive will be disposed at sea in accordance with established Ammunition and Explosives Safety Afloat requirements. The location of any disposal will be recorded. These standard operating procedures benefit public health and safety through a reduction in the potential for interaction with ship shock trial activities.

2.3.3.14 Pile Driving Safety

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. The energy reduction of an individual hammer cannot be quantified because it varies by individual driver. The number of strikes at reduced energy varies because raising the hammer at less than full power and then releasing it results in the hammer “bouncing” as it strikes the pile, which results in multiple “strikes.” This standard operating procedure benefits marine mammals, sea turtles, and fish 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.

2.3.3.15 Sinking Exercise Safety

The Navy is required to conduct sinking exercises greater than 50 NM from land and in waters at least 6,000 ft. deep (40 CFR section 229.2). Within the Study Area, the Navy conducts sinking exercises only within a designated sinking exercise area, as depicted in Figure 2.3-1. The Navy selected the sinking exercise area to avoid established commercial air traffic routes, commercial vessel shipping lanes, and areas used for recreational activities, and to allow for the necessary separation of Navy units to ensure safety for Navy personnel, the public, commercial aircraft and vessels, and Navy assets. These standard operating procedures benefit public health and safety (including persons participating in activities that have socioeconomic value, such as recreational or commercial fishing) through a reduction in the potential for interaction with sinking exercises.

2.3.3.16 Coastal Zone

As a matter of practice, the Navy does not typically conduct certain activities in the coastal zone due to specific mission requirements. The coastal zone extends 3 NM from shore everywhere in the Study Area except off Texas, the Florida Gulf coast, and Puerto Rico, where it extends 9 NM from shore. Training and testing activities that do not typically occur in the coastal zone are listed in Table 2.3-6 and Table 2.3-7, respectively. This standard operating procedure benefits public health and safety and the environmental and cultural resources that are located in the coastal zone through an avoidance of potential interaction with applicable activities.

Table 2.3-6: Training Activities Typically Not Occurring in the Coastal Zone[1]

Air Warfare	*Mine Warfare*

• Air Combat Maneuver[2]
• Air Defense Exercise
• Gunnery Exercises
  o all Air-to-Air
  o all Surface-to-Air
• Missile Exercises
  o Air-to-Air
  o Surface-to-Air
	• Mine Detection
	  o Mine Countermeasure Exercise – Ship Sonar
	• Mine Laying
	  o Aircraft
	  o Submarine launched

Amphibious Warfare	*Surface Warfare*

• Naval Surface Fire Support Exercise-At Sea
• Naval Surface Fire Support Exercise-Land Based Target
	• Gunnery Exercises
	  o All Air-to-Surface
	  o All Surface-to-Surface
	• Missile Exercise
	  o Air-to-Surface (Missile and Rocket)
	  o Surface-to-Surface
	• Laser Targeting
	  o Aircraft
	  o Ship
	• Integrated Live Fire
	• Bombing Exercise
	• Sinking Exercise[3]

Anti-Submarine Warfare	*Major Training Exercise*

• Torpedo Exercise
  o Helicopter
  o Maritime Patrol Aircraft
  o Submarine
  o Ship
• Tracking Exercise
  o Helicopter
  o Maritime Patrol Aircraft
  o Submarine
  o Ship
	• Composite Training Unit Exercise
	• Fleet Exercise/Sustainment Exercise

	Other Training Activities
	• Submarine Navigation • Submarine Under Ice Certification
Integrated/Coordinated Anti-Submarine Warfare	*Electronic Warfare*

• Anti-Submarine Warfare Tactical Development Exercise
• Group Sail
• Navy Undersea Warfare Training Assessment Course
• Surface Warfare Advanced Tactical Training
	• Counter Targeting
	  o Chaff-Aircraft
	  o Chaff-Ship
	  o Flare-Aircraft

[1] The coastal zone extends 3 NM from shore everywhere in the Study Area except off Texas, the Florida Gulf coast, and Puerto Rico, where it extends 9 NM from shore.
[2] Air Combat Maneuver typically occurs outside the coastal zone, with an exception in the Key West Range Complex.
[3] This activity only occurs in a designated area, which is located outside of the coastal zone.

Table 2.3-7: Testing Activities Typically Not Occurring in the Coastal Zone[1]

Air Warfare

- Air Combat Maneuver Test
- Air Platform Weapons Integration Test
- Air Platform-Vehicle Test
- Air-to-Air Weapons System Test
  - Air-to-Air Gunnery Test – Medium-Caliber
  - Air-to-Air Missile Test
- Intelligence, Surveillance, and Reconnaissance Test

Anti-Submarine Warfare

- Anti-Submarine Warfare Torpedo Test
- Anti-Submarine Warfare Tracking Test – Helicopter
- Kilo Dip
- Sonobuoy Lot Acceptance Test
- Torpedo (Explosive) Testing[2]
- At-Sea Sonar Testing
- Anti-Submarine Warfare Tactical Development Exercise

Electronic Warfare

- Chaff Test
- Electronic Systems Evaluation
- Flare Test

Mine Warfare

- Mine Laying Test

Vessel Evaluation

- Aircraft Carrier Sea Trials – Propulsion Testing
- Air Defense Testing
- Propulsion Testing
- Surface Warfare Testing
- Small Ship Shock Trial[2]
- Large Ship Shock Trial[2]
- Submarine Sea Trials – Propulsion Testing
- Submarine Sea Trials – Weapons System Testing
- Total Ship Survivability Trials
- Non-Acoustic Component Testing

Surface Warfare

- Air-to-Surface Bombing Test
- Air-to-Surface Gunnery Test
- Air-to-Surface Missile Test
- High-Energy Laser Weapons Test
- Laser Targeting Test
- Rocket Test
- Gun Testing – Large-Caliber
- Gun Testing – Medium-Caliber
- Gun Testing – Small-Caliber
- Kinetic Energy Weapon Testing
- Missile and Rocket Testing

Other Testing Activities

- Air Platform Shipboard Integrate Test
- Maritime Security
- Shipboard Electronic Systems Evaluation
- Acoustic Component Testing
- Chemical and Biological Simulant Testing (coastal zone of Maine only)
- Hydrodynamic and Maneuverability Testing
- Signature Analysis Operations
- Acoustic and Oceanographic Research
- Emerging Mine Countermeasure Technology Research
- Large Displacement Unmanned Underwater Vehicle Testing

Unmanned Systems

- Underwater Search, Deployment, and Recovery

[1] The coastal zone extends 3 NM from shore everywhere in the Study Area except off Texas, the Florida Gulf coast, and Puerto Rico, where it extends 9 NM from shore.
[2] This activity only occurs in designated areas, which are located outside of the coastal zone.

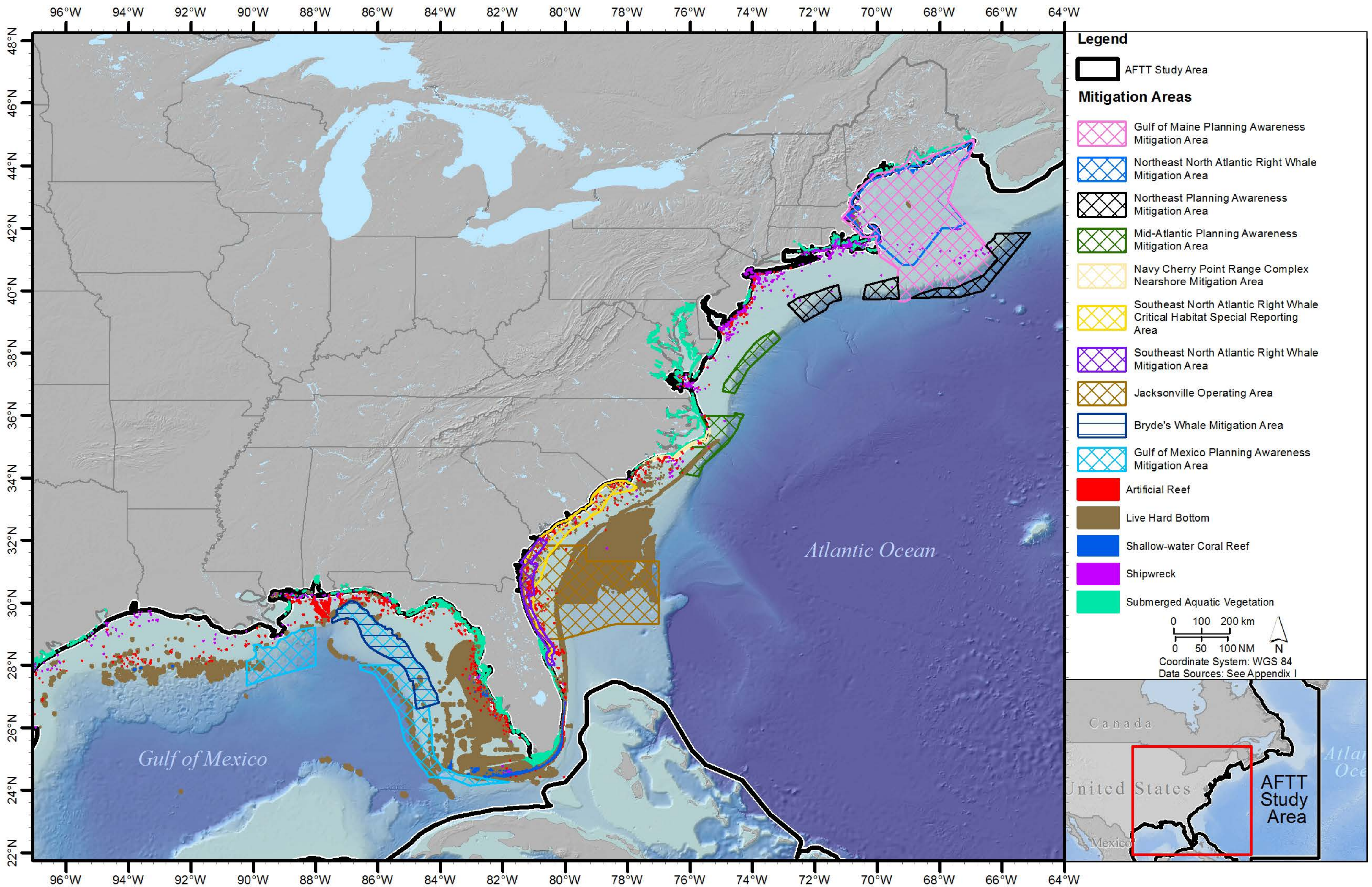
2.3.4 Mitigation Measures

The Navy will implement mitigation measures to avoid or reduce potential impacts from the Proposed Action on environmental and cultural resources, some of which have high socioeconomic value in the Study Area. Mitigation measures that the Navy will implement under the Proposed Action are organized into two categories: procedural mitigation measures and mitigation areas. The Navy will implement procedural mitigation measures whenever and wherever applicable training or testing activities take place within the Study Area. Mitigation areas are geographic locations within the Study Area where the Navy will implement additional mitigation during all or part of the year.

A list of the activity categories, stressors, and geographic locations that have mitigation measures is provided in Table 2.3-8. Chapter 5 (Mitigation) provides a full description of each mitigation measure that will be implemented under the Proposed Action, including a discussion of how the Navy developed and assessed each measure and detailed maps of the mitigation area locations. Relevant mitigation details are also provided throughout Appendix A (Navy Activity Descriptions). The Navy and NMFS Records of Decision, MMPA Regulations and Letters of Authorization, and Endangered Species Act (ESA) Biological Opinion will document all mitigation measures that the Navy will implement under the Proposed Action.

Table 2.3-8: Overview of Mitigation Categories

Mitigation Category	*Chapter 5 (Mitigation) Section*	*Applicable Activity Category, Stressor, or Mitigation Area Location*
Procedural Mitigation	Section 5.3.2 (Acoustic Stressors)	Active Sonar Air Guns Pile Driving Weapons Firing Noise Aircraft Overflight Noise
	Section 5.3.3 (Explosive Stressors)	Explosive Sonobuoys Explosive Torpedoes Explosive Medium-Caliber and Large-Caliber Projectiles Explosive Missiles and Rockets Explosive Bombs Sinking Exercises Explosive Mine Countermeasure and Neutralization Activities Explosive Mine Neutralization Activities Involving Navy Divers Maritime Security Operations – Anti-Swimmer Grenades Line Charge Testing Ship Shock Trials
	Section 5.3.4 (Physical Disturbance and Strike Stressors)	Vessel Movement Towed In-Water Devices Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions Non-Explosive Missiles and Rockets Non-Explosive Bombs and Mine Shapes
Mitigation Areas	Section 5.4 (Mitigation Areas to be Implemented)	Areas with Seafloor Resources Areas off the Northeastern United States Areas off the Mid-Atlantic and Southeastern United States Areas in the Gulf of Mexico



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Ship Sinking Exercises; VACAPES: Virginia Capes

Figure 2.3-2: Summary of Mitigation Areas in the Study Area

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2.4 Action Alternative Development

The identification, consideration, and analysis of alternatives are critical components of the National Environmental Policy Act (NEPA) process and contribute to the goal of objective decision-making. The Council on Environmental Quality issued regulations implementing NEPA, and these regulations require the decision maker to consider the environmental effects of the proposed action and a range of alternatives (including the no action alternative) to the proposed action (40 CFR section 1502.14). Council on Environmental Quality guidance further provides that an EIS must rigorously and objectively explore all reasonable alternatives for implementing the proposed action and, for alternatives eliminated from detailed study, briefly discuss the reasons for having been eliminated. To be reasonable, an alternative, except for the no action alternative, must meet the stated purpose of and need for the proposed action. An alternative that does not meet the stated purpose of and need for the proposed action is not considered reasonable.

The Action Alternatives, and in particular the mitigation measures that are incorporated in the Action Alternatives, were developed to meet both the Navy's purpose and need to train and test, and NMFS's independent purpose and need to evaluate the potential impacts of the Navy's activities, determine whether incidental take resulting from the Navy's activities will have a negligible impact on affected marine mammal species and stocks, and to prescribe measures to effect the least practicable adverse impact on species or stocks and their habitat, as well as monitoring and reporting requirements.

The Navy developed the alternatives considered in this EIS/OEIS after careful assessment by subject matter experts, including military commands that utilize the ranges, military range management professionals, and Navy environmental managers and scientists. The Navy also used new or updated military policy and historical data in developing alternatives.

For example, one military policy used to inform the alternatives development was the Optimized Fleet Response Plan, discussed in Section 1.4.2 (Optimized Fleet Response Plan), which changed how the Navy meets its readiness requirements. The data developed from the Optimized Fleet Response Plan inform the level of training, including the use of sonar sources and explosives, required by the Navy to meet its Title 10 responsibilities, which include maintaining, training, and equipping combat-ready forces. Additionally, during prior phases of comprehensive environmental planning, the Navy assumed that all unit-level sonar training requirements were met through independent training events, meaning each active sonar training requirement was analyzed as a discrete event. This was done for two reasons. First, there was insufficient data to determine if training requirements were being met through means other than live at-sea training, such as through the use of simulated training. Second, since these data were unavailable during prior phases of environmental planning, the Navy wanted to ensure it did not underestimate the potential effects of these activities when seeking MMPA/ESA permits, resulting in permits with insufficient authority to support the Navy's requirements. This could have resulted in the possibility of exceeding permit limits and resulted in non-compliance with the law.

Through the collection of several years of classified sonar use data, the Navy produced a more refined analysis of the amount of sonar usage that the Navy anticipates will be necessary to meet its training and testing requirements, which underlie the development of the action alternatives.

With regards to testing activities, as previously stated, the level of activity in any given year is highly variable and is dependent on technological advancements, emergent requirements identified during operations, and fiscal fluctuations. Therefore, the environmental analysis must consider all testing activities that could possibly occur to ensure that the analysis fully captures the potential environmental effects. These factors were considered in alternatives carried forward for consideration and analyses as described in Section 2.5 (Alternatives Carried Forward).

2.4.1 Training

The analysis of sonar use showed that ships are meeting their active sonar training requirements through a variety of methods. Ships are limited in the number of underway days that are available to conduct at-sea training during the training cycle due to training schedules and constrained fuel resources. Sailors are required to conduct a variety of unit-level training events, throughout all training phases to maintain readiness and conduct this training through a variety of methods, including simulators, unit-level live training at sea, and unit-level training accomplished in conjunction with other training exercises.

Simulators are sufficient to develop basic operator efficiency and can also be used for basic training of watch teams. While this does build proficiency, it cannot replicate the real-world complexities Sailors will have to deal with while deployed. Operating active sonar in the ocean is extremely complex due to numerous environmental factors that affect how sound travels through water, which cannot be realistically replicated. Only by training in the actual ocean environment can ship crews learn how to deal with these rapidly changing parameters and optimize their sensors to locate underwater objects such as submarines and mines. In summary, while simulators are an important tool for attaining and maintaining readiness, they cannot completely replace live training at sea.

To maximize training effectiveness during limited at-sea opportunities, the Navy takes advantage of training events that can meet multiple training requirements. For example, during an integrated or major training exercise that tracks a submarine with active sonar, units can also take credit for their unit-level training requirement to maintain proficiency in tracking submarines with active sonar. In previous environmental analyses, the Navy assumed that each requirement was met through independent training events. However, Navy's analysis has found that, in some instances, multiple requirements (i.e., unit level, integrated, and major training requirements) could be met during one activity. This ability to meet multiple requirements during one activity effectively reduces the number of times the activity needs to be conducted and, therefore, the sound energy transmitted into the water.

The Optimized Fleet Response Plan also influences the amount of active sonar transmitted during training. Under the prior Fleet Response Plan, as discussed in Section 1.4.2 (Optimized Fleet Response Plan), the Navy was required to be prepared to deploy eight carrier strike groups within 6 months. This meant that Navy units had to accomplish all training requirements from the basic phase through the integrated phase in a 6-month period. Although this level of training would occur if the Navy had to respond to a major national security crisis, this level of training has not been conducted in recent years. Instead, the Navy has been responding to significant but more regional challenges through scheduled deployments while still maintaining a stabilizing and continuous presence around the globe. From an environmental planning and permitting perspective, the combination of analyzing a year where world events require certification and deployment of eight carrier strike groups and repeating the maximum certification and deployment requirement every year resulted in the Navy's analyses and permits overestimating the number of training requirements. This also then overestimated the potential effects of that training over the 5-year MMPA incidental take authorization period. Up until this point, the current force structure (the number of ships, submarines, and aircraft) has resulted in significantly less active sonar use than what was analyzed in the previous environmental planning compliance documents and as reflected in the 2013–2018 permits. The Navy considered these data in developing the action alternatives.

2.4.2 Testing

As described in Section 1.4.3 (Why the Navy Tests), there are multiple factors that make it challenging for the Navy to accurately predict future testing requirements. Testing conducted on past systems is not a reliable predictor of future testing duration and tempo, since testing requirements and funding can change. Also, testing of a given system does not occur on a predictable annual cycle but rather in discrete test phases that differ in duration and frequency. Some test phases are relatively short, up to a year, while others can take multiple years. The duration and timing of testing will vary depending on federal funding cycles and the success of past test events. The time, place, and details of future testing depend on scientific developments that are not easy to predict, and experimental designs may evolve with emerging science and technology. Even with these challenges, the Navy makes every effort to accurately forecast all future testing requirements.

In order to adequately support Navy testing requirements that are driven by the need to support fleet readiness, alternatives must have an annual capacity to conduct the research, development, and testing to support the following:

- new systems and new technologies
- upgrades to existing systems
- testing of existing systems after repair and maintenance activities
- lot acceptance testing of systems

Depending on emerging national security interests or threats to U.S. forces, the Navy may begin rapid development projects that were unanticipated at the time of initial environmental planning. Additionally, the potential that naval forces may need to quickly respond to world conflict or evolving threats may mean that sometimes technical evaluation and operational evaluation of a system could be expedited and occur in the same year. Therefore, the planning for future testing must accommodate these emergent requirements as much as possible. Based on these many uncertainties, the Navy's projected testing requirements and requested authorizations for testing within the AFTT Study Area provides the Navy the ability to test to a potential foreseeable annual maximum level. The maximum level is used in the analysis and authorization to ensure that Navy does not underestimate the potential impacts during the analysis. Consequently, Navy testing during any given year of an authorization timeframe can be less than the levels analyzed.

2.4.3 Alternatives Eliminated from Further Consideration

Alternatives eliminated from further consideration are described below. The Navy determined that these alternatives did not meet the purpose of and need for the Proposed Action after a thorough consideration of each.

2.4.3.1 Alternative Training and Testing Locations

Navy ranges have evolved over the decades and, considered together, allow for the entire spectrum of training and testing to occur in a given range complex or testing range. While some unit-level training and some testing activities may require only one training element (airspace, sea surface space, or undersea space), more advanced training and testing events may require a combination of air, surface, and undersea space as well as access to land ranges. The ability to utilize the diverse and multi-dimensional capabilities of each range complex or testing range allows the Navy to develop and maintain high levels of readiness. The Study Area, and the range complexes and testing ranges it contains, has attributes necessary to support effective training and testing. No other locations match the Study Area attributes, which are as follows:

- proximity of range complexes and testing ranges off the east coast of the United States and within the Gulf of Mexico to each other
- proximity to the homeport regions of Norfolk, Virginia; Camp Lejeune in Jacksonville, North Carolina; and Jacksonville, Florida, as well as the Navy command headquarters, training schools, ships, submarines, aircraft squadrons, and Marine Corps forces located in each of those locations
- proximity to shore-based facilities, infrastructure, and the logistical support provided for testing activities
- proximity to military families, minimizing the length of time Sailors and Marines spend deployed away from home and benefitting overall readiness
- presence of unique training and testing ranges, which include the established mine warfare capabilities in the Virginia Capes Range Complex, the instrumented water ranges located at the South Florida Ocean Measurement Facility Testing Range, and naval training beaches located at Marine Corps Base Camp Lejeune capable of supporting large-scale amphibious training events
- environmental conditions (i.e., bathymetry, topography, and weather) found in the Study Area that maximize the training realism and testing effectiveness

The uniquely interrelated nature of the features and attributes of the range complexes and testing ranges located within the Study Area (as detailed in Section 2.1, Description of the Atlantic Fleet Training and Testing Study Area) provides the training and testing support needed for complex military activities. There is no other series of integrated ranges in the Atlantic Ocean that affords this level of operational support and comprehensive integration for range activities. There are no other potential locations in the Atlantic, where roughly half of the U.S. Navy's fleet is located, where land ranges, OPAREAs, undersea terrain and ranges, testing ranges, and military airspace combine to provide the venues necessary for the training and testing realism and effectiveness required to train and certify naval forces ready for combat operations.

2.4.3.2 Simulated Training and Testing Only

The Navy currently uses simulation for training and testing whenever possible (e.g., command and control exercises are conducted without operational forces); however, there are significant limitations, and its use cannot replace live training or testing.

To detect and counter mine shapes and hostile submarines, the Navy uses both passive and active sonar. Sonar proficiency is a complex and perishable skill that requires regular, hands-on training in realistic and diverse conditions. More than 300 extremely quiet, newer-generation submarines are operated by more than 40 nations worldwide, and these numbers are growing. These difficult-to-detect submarines, as well as torpedoes and underwater mines, are true threats to global commerce, national security, and the safety of military personnel. As a result, defense against enemy submarines is a top priority for the Navy. Anti-submarine warfare training and testing activities include the use of active and passive sonar systems and small explosive charges, which prepare and equip Sailors for countering threats. Inability to train with sonar would eliminate or diminish anti-submarine warfare readiness. Failure to detect and defend against hostile submarines can cost lives, such as the 46 Sailors who lost their lives when a Republic of Korea frigate (CHEONAN) was sunk by a North Korean submarine in March 2010.

There are limits to the realism that current simulation technology can presently provide. Unlike live training, computer-based training does not provide the requisite level of realism necessary to attain combat readiness. Today's simulation technology does not permit anti-submarine warfare training with the level of detail required to maintain proficiency. While simulators are used for the basic training of sonar technicians, they are of limited value beyond basic training. A simulator cannot match the dynamic nature of the environment, such as bathymetry and sound propagation properties, or the training activities involving several units with multiple crews interacting in a variety of acoustic environments.

Sonar operators must train regularly and frequently to develop and maintain the skills necessary to master the process of identifying underwater threats in the complex subsurface environment. Sole reliance on simulation would deny service members the ability to develop battle-ready proficiency in the employment of active sonar in the following areas:

- Bottom bounce and other environmental conditions. Sound hitting the ocean floor (bottom bounce) reacts differently depending on the bottom type and depth. Likewise, sound passing through changing currents, eddies, or across differences in ocean temperature, pressure, or salinity is also affected. Both of these are extremely complex and difficult to simulate, and both are common in actual sonar operations.
- Mutual sonar interference. When multiple sonar sources are operating in the vicinity of each other, interference due to similarities in frequency can occur. Again, this is a complex variable that must be recognized by sonar operators but is difficult to simulate with any degree of fidelity.
- Interplay between ship and submarine target. Ship crews, from the sonar operator to the ship's Captain, must react to the changing tactical situation with a real, thinking adversary (a Navy submarine for training purposes). Training in actual conditions with actual submarine targets provides a challenge that cannot be duplicated through simulation.
- Interplay between anti-submarine warfare teams in the strike group. Similar to the interplay required between ships and submarine targets, a ship's crew must react to all changes in the tactical situation, including changes from cooperating ships, submarines, and aircraft.

Similar to the challenges presented in the training situations above, operational testing cannot be based exclusively on computer modeling or simulation either (see 10 United States Code sections 2366 and 2399). At-sea testing provides the critical information on operability and supportability needed by the Navy to make decisions on the procurement of platforms and systems, ensuring that what is purchased performs as expected and that tax dollars are not wasted. This testing requirement is also critical to protecting the Sailors and Marines who depend on these technologies to execute their mission with minimal risk to themselves.

As the acquisition authority for the Navy, the Systems Commands are responsible for administering large contracts for the Navy's procurement of platforms and systems. These contracts include performance criteria and specifications that must be verified to ensure that the Navy accepts platforms and systems that support the warfighter's needs. Although simulation is a key component in platform and systems development, it does not adequately provide information on how a system will perform or whether it will be available to meet performance and other specification requirements because of the complexity of the technologies in development and marine environments in which they will operate. For this reason, at some point in the development process, platforms and systems must undergo at-sea or in-flight testing. Therefore, simulation as an alternative that replaces training and testing in the field does not meet the purpose of and need for the Proposed Action and has been eliminated from detailed study.

2.4.3.3 Training and Testing Without the Use of Active Sonar

As explained in Section 2.4.3.2 (Simulated Training and Testing Only), in order to detect and counter submerged mines and hostile submarines, the Navy uses both passive and active sonar. Sonar proficiency is a complex and perishable skill that requires regular, hands-on training in realistic and diverse conditions. Active sonar is needed to find and counter newer-generation submarines around the world, which are growing in number, as are torpedoes and underwater mines, which are true threats to global commerce, national security, and the safety of military personnel. As a result, defense against enemy submarines is a top priority for the Navy.

2.4.3.4 Alternatives Including Geographic Mitigation Measures Within the Study Area

The Navy considered developing an alternative based solely on geographic mitigation that would impose time/area restrictions on an expanded list of specific areas in the AFTT Study Area associated with the presence of specific species. However, such an alternative would present a patchwork of areas and time periods in which the Navy could conduct required training and testing, preventing the Navy from conducting the full scope of activities necessary to fulfill its Title 10 responsibilities and running counter to the purpose and need of the Proposed Action. Thus, such an alternative would not be reasonable. Further, regulations governing NEPA allow agencies to “Include appropriate mitigation measures not already included in the proposed action or alternatives” (40 CFR 1502.14[f]). Under both action alternatives carried forward, the Navy would implement limited geographic mitigation areas that are biologically supported and practicable to implement. Such areas are more fully described in Chapter 5 (Mitigation). Therefore, appropriate mitigation protective of impacted species would be implemented regardless of the alternative selected.

2.5 ALTERNATIVES CARRIED FORWARD

The Navy’s anticipated level of training and testing activity evolves over time based on numerous factors as discussed in the preceding paragraphs in Section 2.4 (Action Alternative Development). Additionally, over the past several years, the Navy’s ongoing sonar reporting program has gathered classified data regarding the number of hull-mounted mid-frequency sonar hours used to meet anti-submarine warfare requirements, which has increased understanding of how sonar training hours are generated. These data allow for a more accurate projection of the number of active sonar hours required to meet anti-submarine warfare training requirements into the reasonably foreseeable future.

In light of this information, the Navy was able to better formulate a range of reasonable alternatives that meet Navy training requirements while reflecting a lower, and more realistic, impact on the environment. This analysis of ongoing activities also provides a more accurate assessment of the Navy’s current impact on the environment from ongoing Navy training and testing when compared to the currently permitted activities.

As previously discussed, in addition to meeting Navy’s purpose and need to train and test, the Action Alternatives, and in particular the mitigation measures that are incorporated in the Action Alternatives, were developed to meet NMFS’s independent purpose and need to evaluate the potential impacts of the Navy’s activities, determine whether incidental take resulting from the Navy’s activities will have a negligible impact on affected marine mammal species and stocks, and prescribe measures to effect the least practicable adverse impact on species or stocks and their habitat, as well as monitoring and reporting requirements.

2.5.1 No Action Alternative

As mentioned above in Section 2.4 (Action Alternative Development), the Council on Environmental Quality implementing regulations require that a range of alternatives to the proposed action, including a no action alternative, be analyzed to provide a clear basis for choice among options by the decision maker and the public (40 CFR 1502.14). Council on Environmental Quality guidance identifies two approaches in developing the no action alternative (46 *Federal Register* 18026). One approach for activities that have been ongoing for long periods of time is for the No Action Alternative to be thought of in terms of continuing the present course of action or current management direction or intensity, such as the continuation of Navy training and testing at sea in the AFTT Study Area at current levels, even if separate legal authorizations under the MMPA and ESA are required. Under this approach, which was used in Phases I and II of the Navy's environmental planning and compliance program for training and testing activities at sea, the analysis compares the effects of continuing current activity levels (i.e., the "status quo") with the effects of the Proposed Action. The second approach depicts a scenario where no authorizations or permits are issued, the Navy's training and testing activities do not take place, and the resulting environmental effects from conducting no training or testing are compared with the effects of the Proposed Action. This approach is being applied in Phase III of the Navy's environmental planning and compliance program, including in this EIS/OEIS.

Under the No Action Alternative analyzed in this EIS/OEIS, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Consequently, the No Action Alternative of not conducting the proposed live, at-sea training and testing in the AFTT Study Area is inherently unreasonable in that it does not meet the Navy's purpose and need (see Section 1.4, Purpose and Need) for the reasons noted in the next four paragraphs. However, the analysis associated with the No Action Alternative is carried forward in order to compare the magnitude of the potential environmental effects of the Proposed Action with the conditions that would occur if the Proposed Action did not occur (see Section 3.0, Introduction).

From NMFS's perspective, pursuant to its obligation to grant or deny permit applications under the MMPA, the No Action Alternative involves NMFS denying Navy's application for an incidental take authorization under section 101(a)(5)(A) of the MMPA. If NMFS were to deny the Navy's application, the Navy would not be authorized to incidentally take marine mammals in the AFTT Study Area, and under the No Action Alternative, as explained above, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area.

Cessation of proposed Navy at-sea training and testing activities would mean that the Navy would not meet its statutory requirements and would be unable to properly defend itself and the United States from enemy forces, unable to successfully detect enemy submarines, and unable to effectively use its weapons systems or defensive countermeasures. Navy personnel would essentially not be taught how to use Navy systems in any realistic scenario. For example, sonar proficiency, which is a complex and perishable skill, requires regular, hands-on training in realistic and diverse conditions in order to detect and counter hostile submarines. Inability to train with active sonar would result in no or greatly diminished anti-submarine warfare capability.

Additionally, without proper training, individual Sailors and Marines serving onboard Navy vessels would not be taught how to properly operate complex equipment in inherently dynamic and dangerous environments. Even with high levels of training and a culture of safety, injuries and death have occurred during routine non-combat operations. Therefore, without proper training, it is likely that there would be an increase in the number of mishaps, potentially resulting in the death or serious injury of Sailors and Marines. Failing to allow our Sailors and Marines to achieve and maintain the skills necessary to defend the United States and its interests will result in an unacceptable increase in the danger they willingly face.

Finally, the lack of live training and testing would require a higher reliance on simulated training and testing. While the Navy continues to research new ways to provide realistic training through simulation, there are limits to the realism that current technology can provide. While simulators are used for the basic training of sonar technicians, they are of limited utility beyond basic training. A simulator cannot match the dynamic nature of the environment, such as bathymetry and sound propagation properties, or the training activities involving several units with multiple crews interacting in a variety of acoustic environments. Sole reliance on simulation would deny service members the ability to develop battle-ready proficiency in the employment of active sonar (Section 2.4.3.2, Simulated Training and Testing Only).

2.5.2 Alternative 1

Alternative 1 is the Preferred Alternative.

2.5.2.1 Training

Under this alternative, 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 subject to previous analysis that are currently ongoing and have historically occurred in the Study Area. The requirements for the types of activities to be conducted, as well as the intensity at which they need to occur, have been validated by senior Navy leadership. Specifically, training activities are based on the requirements of the Optimized Fleet Response Plan and on changing world events, advances in technology, and Navy tactical and strategic priorities. These 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 and locations of all proposed training activities are provided in Section 2.6.1 (Proposed Training Activities).

Alternative 1 reflects a representative year of training to account for the natural fluctuation of training cycles and deployment schedules that generally influence the maximum level of training that may occur year after year in any 5-year period. Using a representative level of activity, rather than a maximum tempo of training activity in every year, has reduced the amount of hull-mounted mid-frequency active sonar estimated to be necessary to meet training requirements, as discussed below. Both unit-level training and major training exercises are adjusted to meet this representative year, as discussed below.

Under Alternative 1, the Navy assumes that some unit-level training would be conducted using synthetic means (e.g., simulators). Additionally, this alternative assumes that some unit-level active sonar training will be completed through other training exercises. By using a representative level of training activity rather than a maximum level of training activity in every year, this alternative accepts a degree of risk that if global events necessitated a rapid expansion of military training that Navy would not have sufficient capacity in its MMPA and ESA authorizations to carry out those training requirements.

The Optimized Fleet Response Plan and various training plans identify the number and duration of training cycles that could occur over a 5-year period. Alternative 1 considers 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. Similar to unit-level training, this alternative does not analyze a maximum number carrier strike group Composite Training Unit Exercises (one type of major exercise) every year but instead assumes a maximum number of exercises would occur during 2 years of any 5-year period. As a result, Alternative 1 will analyze a maximum of 3 Composite Training Unit Exercises in any given year and not more than 12 over any 5-year period. This alternative does not provide for the conduct of a contingency Composite Training Unit Exercise in the Gulf of Mexico and, hence, incorporates a degree of risk that the Navy will not have sufficient capacity in potential MMPA permits to support the full spectrum of training potentially necessary to respond to a future national emergency crisis.

This risk associated with the Preferred Alternative was deemed acceptable by the Commander of all Naval forces in the Study Area based on training requirements needed to meet the current geopolitical environment. The acceptance of this risk was contingent on using the best available science to conduct a thorough analysis of impacts from Alternative 2, including annual maximum levels of unit-level active sonar hours, Composite Training Unit Exercises, and contingency Composite Training Unit Exercises in the Gulf of Mexico.

2.5.2.2 Testing

Alternative 1 entails a level of testing activities to be conducted into the reasonably foreseeable future, with adjustments that account for changes in the types and tempo (increases or decreases) of testing activities to meet current and future military readiness requirements. This alternative includes the testing of new platforms, systems, and related equipment that will be introduced after November 2018. The majority of testing activities that would be conducted under this alternative are the same as or similar as those conducted currently or in the past. This alternative includes the testing of some new systems using new technologies and takes into account inherent uncertainties in this type of testing.

Under Alternative 1, the Navy proposes an annual level of testing that reflects the fluctuations in testing programs by recognizing that the maximum level of testing will not be conducted each year. This alternative contains a more realistic annual representation of activities, but includes years of a higher maximum amount of testing to account for these fluctuations. This alternative would not include the contingency for augmenting some weapon system tests, which would increase levels of annual testing of anti-submarine warfare and mine warfare systems, and presumes a typical level of readiness requirements. The numbers and locations of all proposed testing activities are provided in Section 2.1.1 (Proposed Testing Activities).

2.5.2.3 Mitigation Measures

The Navy’s entire suite of mitigation measures was developed in coordination with NMFS and applied to Alternative 1 to ensure that (1) the benefit of mitigation measures to environmental and cultural resources was considered during the applicable environmental analyses and (2) Navy senior leadership approved each mitigation measure that would be implemented under Alternative 1. Navy senior leadership reviewed relevant supporting information to make a fully informed decision, including the benefit of mitigation measures to environmental and cultural resources and the impacts that mitigation will have on training and testing activities under Alternative 1. As discussed in Chapter 5 (Mitigation), the mitigation measures represent the maximum level of mitigation that the Navy can implement after consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activities.

2.5.3 Alternative 2

2.5.3.1 Training

As under Alternative 1, this alternative includes new and ongoing activities. Under Alternative 2, training activities are based on requirements established by the Optimized Fleet Response Plan. Under this alternative, the Navy would be enabled to meet the highest levels of required military readiness by conducting the majority of its training live at sea and by meeting unit-level training requirements using dedicated, discrete training events, instead of combining them with other training activities as described for Alternative 1. The numbers and locations of all proposed training activities are provided in Section 2.6.1 (Proposed Training Activities), Table 2.6-1.

Alternative 2 reflects the maximum number of training activities that could occur within a given year and assumes that the maximum level of activity would occur every year over any 5-year period. This allows for the greatest capacity for the Navy to maintain readiness when considering potential changes in the national security environment, fluctuations in training and deployment schedules, and potential in-theater demands. Both unit-level training and major training exercises are assumed to occur at a maximum level every year.

Additionally, this alternative will analyze 3 Composite Training Unit Exercises each year along with a contingency Composite Training Unit Exercise in the Gulf of Mexico each year, for a total number of 20 Composite Training Unit Exercises, including the Gulf of Mexico contingency Composite Training Unit Exercise, over any 5-year period.

2.5.3.2 Testing

Like Alternative 1, Alternative 2 entails a level of testing activities to be conducted into the reasonably foreseeable future and includes the testing of new platforms, systems, and related equipment that will be introduced beginning in November 2018. The majority of testing activities that would be conducted under this alternative are the same as or similar to those conducted currently or in the past.

Alternative 2 would include the testing of some new systems using new technologies, taking into account the potential for delayed or accelerated testing schedules, variations in funding availability, and innovations in technology development. To account for these inherent uncertainties in testing, this alternative assumes that the maximum annual testing efforts predicted for each individual system or program could occur concurrently in any given year. This alternative also includes the contingency for augmenting some weapon systems tests in response to potential increased world conflicts and changing Navy leadership priorities as the result of a direct challenge from a naval opponent that possesses near-peer capabilities. Therefore, this alternative includes the provision for higher levels of annual testing of certain anti-submarine warfare and mine warfare systems to support expedited delivery of these systems to the fleet. All proposed testing activities are listed in Table 2.6-2 through Table 2.6-4, Section 2.6 (Proposed Training and Testing Activities for Both Alternatives).

2.5.3.3 Mitigation Measures

The Navy's entire suite of mitigation measures was developed in coordination with NMFS and applied to Alternative 1 to ensure that (1) the benefit of mitigation measures to environmental and cultural resources was considered during the applicable environmental analyses and (2) Navy senior leadership approved each mitigation measure that would be implemented under Alternative 1. Navy senior leadership reviewed relevant supporting information to make a fully informed decision, including the benefit of mitigation measures to environmental and cultural resources and the impacts that mitigation will have on training and testing activities under Alternative 1. As discussed in Chapter 5 (Mitigation), the mitigation measures represent the maximum level of mitigation that the Navy can implement after consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activities.

2.5.4 Comparison of Proposed Sonar and Explosive Use in the Action Alternatives to the 2013–2018 MMPA Permit Allotment

2.5.4.1 Training

As a comparison to the amount of training analyzed in the previous environmental planning compliance documents and as reflected in the 2013–2018 MMPA permit (Phase II), the Navy considered the type of sonar source that resulted in the greatest number of exposures to marine mammals, which was identified as hull-mounted mid-frequency active sonar. The differences between use of this system from Phase II to Phase III are best identified in three ways: (1) completion of unit-level training via synthetic means or through other training exercises, (2) reduction of sonar hours associated with a Composite Training Unit Exercise, and (3) reduction in the number of Composite Training Unit Exercises expected over a 5-year period.

During Phase II, all unit-level training using hull-mounted mid-frequency sonar was assumed to be conducted during discrete training events. However, current practice indicates that some unit-level training is completed through synthetic training, as well as concurrent with other training exercises (e.g., unit-level training can be completed simultaneously during the conduct of an integrated training exercise). Alternative 1 accounts for the use of synthetic training and concurrent unit-level training within other exercises, although this assumes risk in the event additional live training is necessary. To preserve the ability for the Navy to conduct all unit-level sonar training as discrete, at-sea exercises, Alternative 2 does not provide for the reduction in hours for this type of activity.

Composite Training Unit Exercises are major exercises that involve multiple platforms and numerous hours of sonar to meet mission objectives. During Phase II, each Composite Training Unit Exercise was assumed to require 1,000 hours of hull-mounted mid-frequency sonar. Through analysis of data collected during the Phase II permit period, the Navy determined that this assumption overestimated the amount of hull-mounted mid-frequency sonar that was typically used in a Composite Training Unit Exercise by 400 hours. As such, for both Alternatives 1 and 2, an estimated 600 hours of hull-mounted mid-frequency sonar is included for each Composite Training Unit Exercise.

Comparisons of proposed hull-mounted mid-frequency sonar hours to the hours permitted from 2013 to 2018 are depicted in Figure 2.5-1 and Figure 2.5-2.

The Fleet Response Plan, in place during Phase II, identified a requirement to conduct four Composite Training Unit Exercises per year along the U.S. East Coast, and a contingency Composite Training Unit Exercise in the Gulf of Mexico was also included, resulting in a total of five exercises analyzed per year. For Phase III, the number of Composite Training Unit Exercises to be conducted is reduced, with fewer proposed exercises in Alternative 1 and Alternative 2. Alternative 1 reduces the number of Composite Training Unit Exercises to be conducted during any 5-year period along the east coast from the 2013–2018 permitted level by analyzing representative years (in addition to maximum planned years) of training activity to account for the variability of training cycles and deployment schedules. Alternative 1 analysis includes no more than 12 Composite Training Unit Exercises over any 5-year period into the

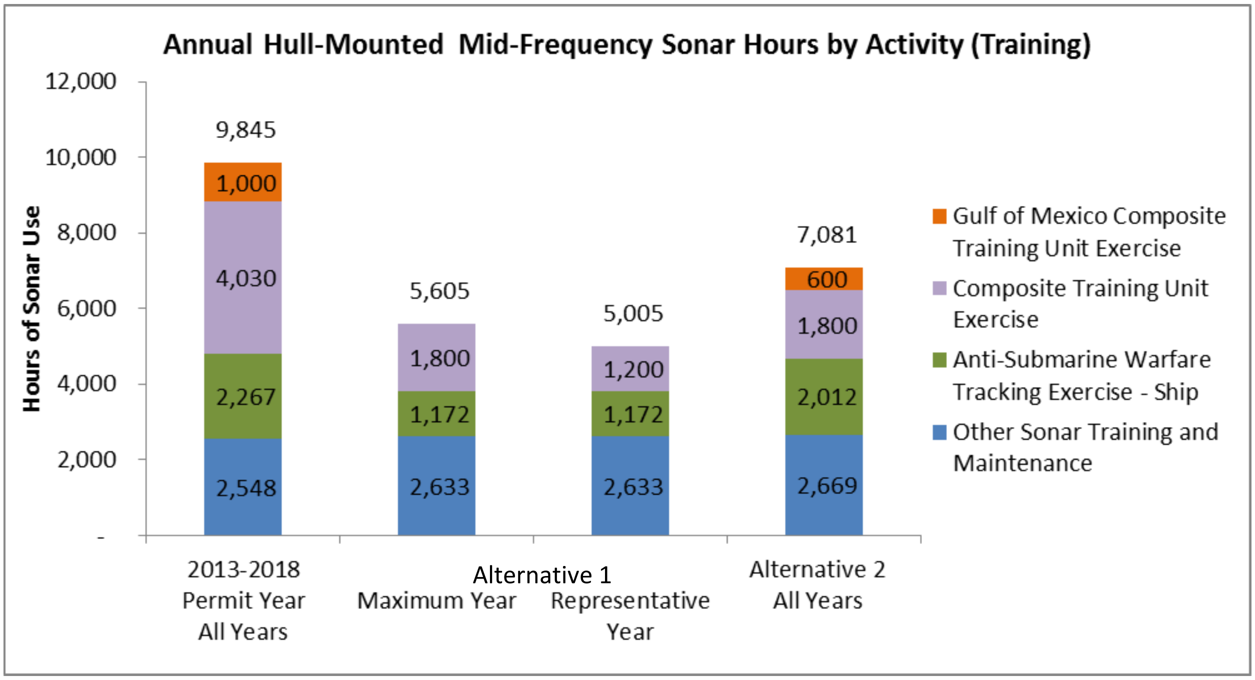


Figure 2.5-1: Proposed Maximum Year of Hull-Mounted Mid-Frequency Sonar Hour Use by Activity During Training Compared to the Number Authorized in the 2013–2018 Marine Mammal Protection Act Permit

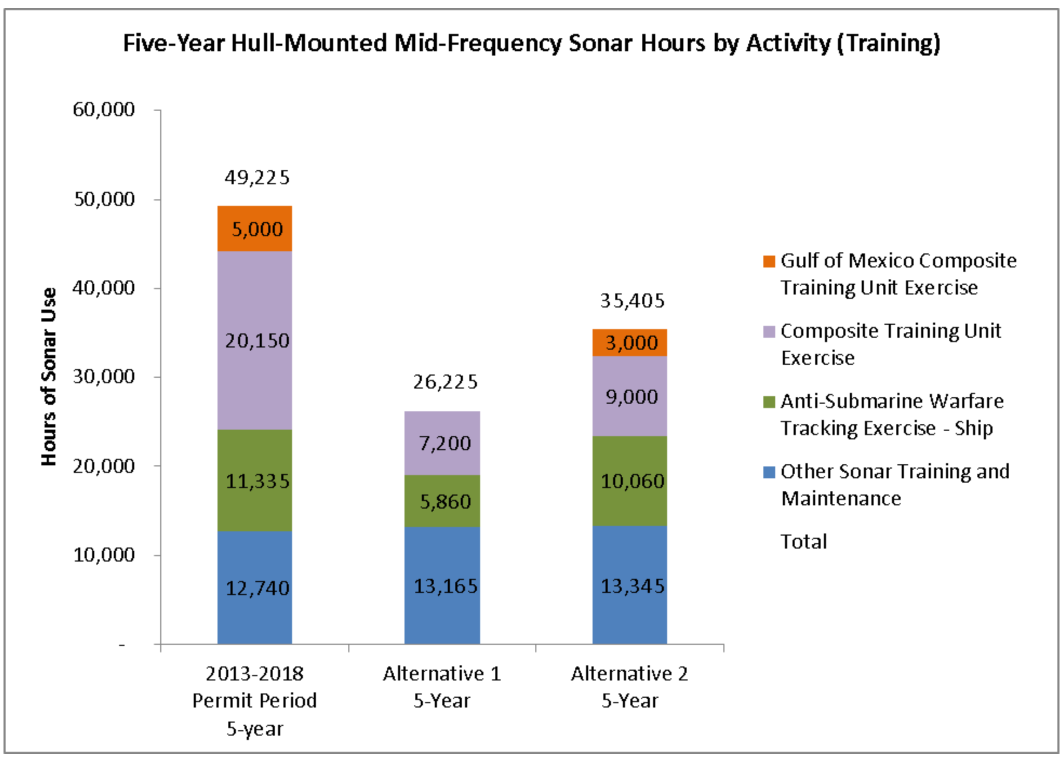


Figure 2.5-2: Proposed Five-Year Total Hull-Mounted Mid-Frequency Sonar Hour Use by Activity During Training Compared to the Number Authorized in the 2013–2018 Marine Mammal Protection Act Permit

foreseeable future. Alternative 2 analyzes a maximum number of Composite Training Unit Exercises planned per year (three) along the east coast and a contingency exercise in the Gulf of Mexico every year in a 5-year period. As such, Alternative 2 provides for 4 Composite Training Unit Exercises each year, for a total of 20 over a 5-year period. A comparison of the number of Composite Training Unit Exercises from the 2013–2018 permitted levels to the action alternatives is provided in Figure 2.5 3.

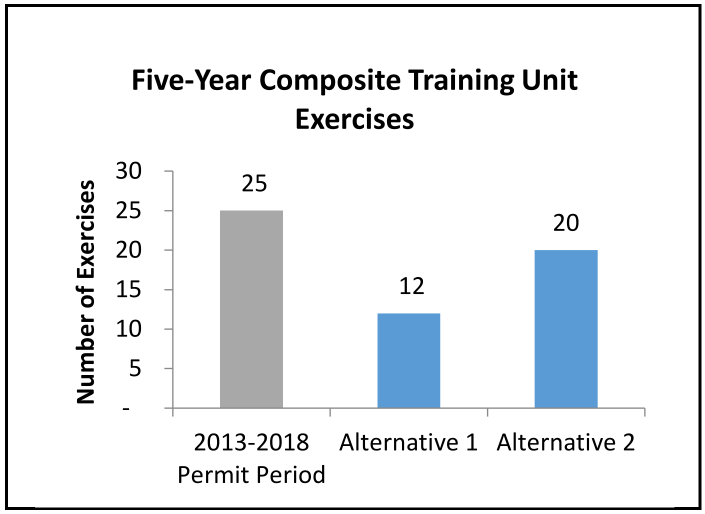
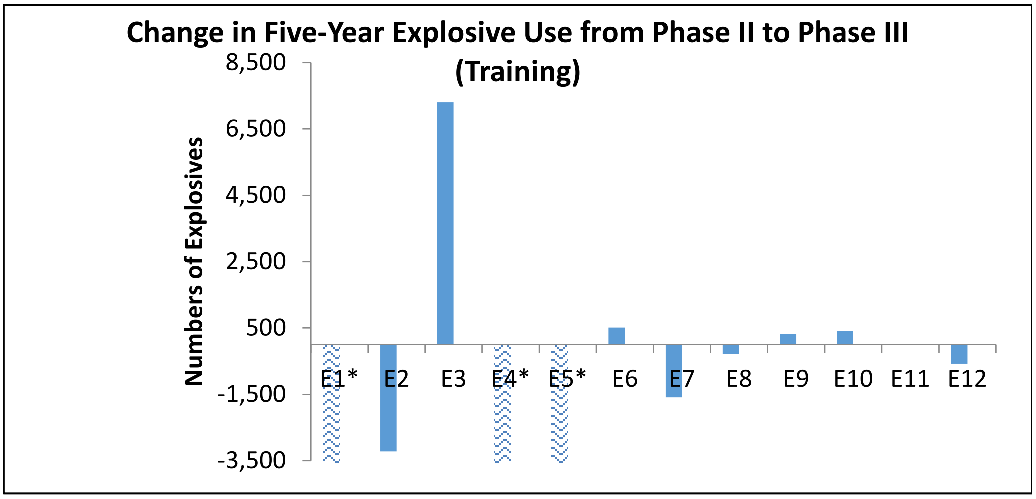


Figure 2.5-3: Proposed Number of Composite Training Unit Exercises over a Five-Year Period Compared to Number Authorized in the 2013–2018 Marine Mammal Protection Act Permit

After analyzing the level of explosive activities conducted during Phase II, the Navy identified that some explosive sources were incorrectly classed into bins with greater net explosive weights than are actually present in the munitions (see Section 3.0.3.3.2.1, Explosions in Water, for a discussion of explosive classification bins). For example, 20-millimeter rounds were considered in bin E1 during Phase II, but have less than 0.1 pound of net explosive weight (defined as bin E0) and are, therefore, analyzed qualitatively instead of quantitatively for Phase III. Additionally in Phase II, munitions within the same category were all analyzed with the highest net explosive weight for all munitions in that category. For example, most bombs were analyzed as bin E12 to account for the largest potential for environmental impact, whereas many fall within bins E9 and E10. For Phase III, munitions were divided into more appropriate bins based on current and anticipated weapon inventory. Due to the re-binning of multiple munitions, comparing the use of a single bin or type of explosive (similar to the comparison above for sonar) is not prudent. Figure 2.5-4 provides the change in explosive use per bin for all training activities between the 2013–2018 permitted level and the two action alternatives.

2.5.4.2 Testing

As described in Sections 1.4.3.2 (Methods of Testing), 2.5.2.2 (Testing), and 2.5.3.2 (Testing), the Navy's testing community faces a number of challenges in accurately defining future testing requirements. These challenges include varying funding availability, changes in Congressional and DoD/Navy priorities in response to emerging threats in the world, and the acquisition of new technologies that introduce increased uncertainties in the timeline, tempo, or success of a system's testing schedule. As it does now, the Navy testing community took into account these same challenges in projecting requirements for the 2013–2018 (Phase II) testing timeframe. Although the best information available to the Navy has always been taken into account, as a result of the implementation of Phase II, the Navy testing community has improved its ability to obtain and define that information and, consequently, its ability to project future testing needs. It is expected that over time, the Navy's ability to project future testing requirements will continue to improve with increasing refinement of the process and more or better historical data. Nonetheless, the inherent challenges and uncertainties in testing, as described previously, will continue to make projection of future testing requirements challenging.



* Bin E1 decreased by 571,060 explosives, bin E4 decreased by 10,303 explosives, and bin E5 decreased by 51,150 explosives. These bins cannot be represented in this graph without distorting the scale.
1 Alternative 1 and Alternative 2 would use the same number of explosives in Phase III; bar graph depicts both alternatives.
2 As the graph indicates the change in explosive use, the 2013–2018 permitted level is represented as the "0" line, to which the change for Phase III is compared, such that positive values are an increase in use of the bin and negative values are a decrease in use of that bin.

Figure 2.5-4: Change in Explosive Use (for Both Action Alternatives) During Training Activities Compared to the 2013–2018 Marine Mammal Protection Act Permit[1, 2]

The majority of platforms, weapons, and systems that were proposed for testing during the Phase II timeframe are the same or very similar to those proposed to be tested in the future. However, the Navy projects that the need to test some platforms, weapons, and systems will increase, while others will decrease, as compared to the testing requirements that were proposed for the Phase II timeframe. Overall, the Navy is projecting a net increase in the need to test systems that use sonar and a net decrease for explosives use, as proposed under Alternative 1 and as compared to the proposed testing requirements of the Phase II timeframe. These future projections are based on improvements in the Navy's understanding of requirements, the completion of test phases of certain projects since Phase II, the addition of test phases anticipated to start after December 2018, and the projected testing of new types of equipment since the 2013–2018 timeframe.

2.6 Proposed Training and Testing Activities for Both Alternatives

2.6.1 Proposed Training Activities

All proposed training activities are listed in Table 2.6-1. It should be noted that many of the activities listed occur the same number of time annually under both alternatives. These activities can be thought of as meeting individual training requirements. Although the number of some activities may be the same, the difference between the alternatives is manifest in how these activities are conducted. This difference is explained above in Section 2.5 (Alternatives Carried Forward) and represented in Figure 2.5-1 and Figure 2.5-2.

Table 2.6-1: Proposed Training Activities per Alternative

Activity Name	Annual # of Activities[a]		5-Year # of Activities		Location[b]
	Alt 1	Alt 2	Alt 1	Alt 2	
Major Training Exercise – Large Integrated Anti-Submarine Warfare					
Composite Training Unit Exercise	2–3	3	12	15	VACAPES RC Navy Cherry Point RC JAX RC
	0	1	0	5	GOMEX
Major Training Exercise – Medium Integrated Anti-Submarine Warfare					
Fleet Exercise/Sustainment Exercise	2		10		VACAPES RC
	4		20		JAX RC
Integrated/Coordinated Training					
Small Integrated Anti-Submarine Training	6		30		JAX RC
	3		15		Navy Cherry Point RC
	3		15		VACAPES RC
Medium Coordinated Anti-Submarine Warfare Training	2		10		JAX RC
	1		5		Navy Cherry Point RC
	1		5		VACAPES RC
Small Coordinated Anti-Submarine Warfare Training	4		20		JAX RC
	5		25		Navy Cherry Point RC
	5		25		VACAPES RC
Air Warfare					
Air Combat Maneuver	1,270		6,350		JAX RC
	6,300		31,500		Key West RC
	1,155		5,775		Navy Cherry Point RC
	1,200		6,000		VACAPES RC
Air Defense Exercise	85		425		GOMEX RC
	5,157		25,785		JAX RC
	5,166		25,830		Navy Cherry Point RC
	3,425		17,125		VACAPES RC
Gunnery Exercise Air-to-Air Medium-Caliber	75		375		JAX RC
	70		350		Key West RC
	40		200		Navy Cherry Point RC
	120		600		VACAPES RC
Gunnery Exercise Surface-to-Air Large Caliber	7		35		JAX RC
	25		125		VACAPES RC
Gunnery Exercise Surface-to-Air Medium Caliber	10		50		Other AFTT Areas[1]
	31		155		JAX RC
	23		115		Navy Cherry Point RC
	59		295		VACAPES RC
Missile Exercise Air-to-Air	48		240		JAX RC
	8		40		Key West RC
	48		240		Navy Cherry Point RC
	40		200		VACAPES RC
Missile Exercise Surface-to-Air	2		10		GOMEX RC
	5		20		JAX RC
	2		10		Navy Cherry Point RC
	2		10		Northeast RC
	30		50		VACAPES RC

Table 2.6-1: Proposed Training Activities per Alternative (continued)

Activity Name	Annual # of Activities[a]		5-Year # of Activities		Location[b]
	Alt 1	Alt 2	Alt 1	Alt 2	
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		JAX 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		VACAPES RC
	2		10		JAX 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		GOMEX
	12		60		JAX RC
	2		10		Navy Cherry Point RC
	38		190		VACAPES RC
Naval Surface Fire Support Exercise – Land–Based Target	13		65		Navy Cherry Point RC
Anti-Submarine Warfare					
Anti-Submarine Warfare Torpedo Exercise – Helicopter	14		70		JAX RC
	4		20		VACAPES RC
Anti-Submarine Warfare Torpedo Exercise – Maritime Patrol Aircraft	14		70		JAX RC
	4		20		VACAPES RC
Anti-Submarine Warfare Torpedo Exercise – Ship	16		80		JAX RC
	5		25		VACAPES RC
Anti-Submarine Warfare Torpedo Exercise – Submarine	12		60		JAX RC
	6		30		Northeast RC
	2		10		VACAPES RC
Anti-Submarine Warfare Tracking Exercise – Helicopter	24		120		Other AFTT Areas
	370		1,850		JAX RC
	12		60		Navy Cherry Point RC
	8		40		VACAPES RC
Anti-Submarine Warfare Tracking Exercise – Maritime Patrol Aircraft	90		450		Northeast RC
	176		880		VACAPES RC
	525		2,625		JAX RC
	46		230		Navy Cherry Point RC
	5[c]	5	25[c]	25	Northeast RC

Table 2.6-1: Proposed Training Activities per Alternative (continued)

Activity Name	Annual # of Activities[a]		5-Year # of Activities		Location[b]
	Alt 1	Alt 2	Alt 1	Alt 2	
Anti-Submarine Warfare Tracking Exercise – Ship	110[c]	110	550[c]	550	Other AFTT Areas
	5[c]	5	25[c]	25	GOMEX RC
	440[c]	440	2,200[c]	2,200	JAX RC
	55[c]	55	275[c]	275	Navy Cherry Point RC
	220[c]	220	1,100[c]	1,100	VACAPES RC
Anti-Submarine Warfare Tracking Exercise – Submarine	44		220		Other AFTT Areas
	13		65		JAX RC
	1		5		Navy Cherry Point RC
	18		90		Northeast RC
	6		30		VACAPES RC
Electronic Warfare					
Counter Targeting Chaff Exercise – Aircraft	18		90		GOMEX RC
	2,990		14,950		JAX RC
	3,000		15,000		Key West RC
	1,610		8,050		Navy Cherry Point RC
	130		650		VACAPES RC
Counter Targeting Chaff Exercise – Ship	5		25		GOMEX RC
	5		25		JAX RC
	5		25		Navy Cherry Point RC
	50		250		VACAPES RC
Counter Targeting Flare Exercise	92		460		GOMEX RC
	1,900		9,500		JAX RC
	1,550		7,750		Key West RC
	1,115		5,575		Navy Cherry Point RC
	50		250		VACAPES RC
Electronic Warfare Operations	181		905		JAX RC
	2,620		13,100		Navy Cherry Point RC
	302		1,510		VACAPES RC
High-Speed Anti-Radiation Missile Exercise	4		20		JAX RC
	10		50		Navy Cherry Point RC
	11		55		VACAPES RC
Expeditionary Warfare					
Dive and Salvage Operations	16		80		GOMEX RC
	60		300		JAX RC
	8		40		Key West RC
	16		80		Navy Cherry Point RC
	30		150		VACAPES RC
Maritime Security Operations – Anti-Swimmer Grenades	2		10		GOMEX RC
	2		10		JAX RC
	2		10		Navy Cherry Point RC
	4		20		Northeast RC
	5		25		VACAPES RC
Personnel Insertion/ Extraction – Air	10		50		JAX RC
	10		50		Key West
	2,164		10,820		VACAPES RC
	2		10		Northeast RC

Table 2.6-1: Proposed Training Activities per Alternative (continued)

Activity Name	Annual # of Activities[a]		5-Year # of Activities		Location[b]
	Alt 1	Alt 2	Alt 1	Alt 2	
Personnel Insertion/ Extraction – Surface and Subsurface	5		25		GOMEX RC
	1		5		JAX RC
	360		1,800		VACAPES RC
Personnel Insertion/ Extraction – Swimmer/Diver	42		210		VACAPES RC
Underwater Construction Team Training	8		40		GOMEX RC
	4		20		JAX RC
	4		20		Key West RC
	8		40		VACAPES RC
Mine Warfare					
Airborne Mine Countermeasure – Mine Detection	66		330		GOMEX RC
	317		1,585		JAX RC
	371		1,855		Navy Cherry Point RC
	244		1,220		NSWC Panama City
	1,540		7,700		VACAPES RC
Airborne Mine Countermeasures – Towed Mine Neutralization	50		250		GOMEX RC
	100		500		JAX RC
	108		540		Navy Cherry Point RC
	510		2,550		VACAPES 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 GOMEX RC Hampton Roads, VA JAX RC Kings Bay, GA NS Mayport Morehead City, NC Port Canaveral, FL Savannah, GA Tampa, FL VACAPES RC Wilmington, NC
Coordinated Unit Level Helicopter Airborne Mine Countermeasure Exercise	2		10		GOMEX RC
	2		10		JAX RC
	2		10		Navy Cherry Point RC
	2		10		VACAPES RC
Mine Countermeasures – Mine Neutralization – Remotely Operated Vehicle	132		660		GOMEX RC
	71		355		JAX RC
	71		355		Navy Cherry Point RC
	630		3,150		VACAPES RC
Mine Countermeasures – Ship Sonar	22		110		GOMEX RC
	53		265		JAX RC
	53		265		VACAPES RC

Table 2.6-1: Proposed Training Activities per Alternative (continued)

Activity Name	Annual # of Activities[a]		5-Year # of Activities		Location[b]
	Alt 1	Alt 2	Alt 1	Alt 2	
Mine Laying	1		5		JAX RC
	2		10		Navy Cherry Point RC
	4		20		VACAPES RC
Mine Neutralization – Explosive Ordnance Disposal	6		30		Lower Chesapeake Bay
	16		80		GOMEX RC
	20		100		JAX RC
	17		85		Key West RC
	16		80		Navy Cherry Point RC
	524		2,620		VACAPES RC
Underwater Mine Countermeasures Raise, Tow, Beach, and Exploitation Operations	56		280		GOMEX RC
	78		390		JAX RC
	8		40		Key West RC
	24		120		Navy Cherry Point RC
	446		2,230		VACAPES RC
Surface Warfare					
Bombing Exercise Air-to-Surface	67		335		GOMEX RC
	434		2,170		JAX RC
	108		540		Navy Cherry Point RC
	329		1645		VACAPES RC
Fast Attack Craft and Fast Inshore Attack Craft Exercise	25		125		JAX RC
	25		125		VACAPES RC
Gunnery Exercise Air-to-Surface Medium-Caliber	30		150		GOMEX RC
	495		2,475		JAX RC
	395		1,975		Navy Cherry Point RC
	720		3,600		VACAPES RC
Gunnery Exercise Air-to-Surface Small-Caliber	200		1,000		JAX RC
	130		650		Navy Cherry Point RC
	560		2,800		VACAPES RC
Gunnery Exercise Surface-to-Surface Boat Medium-Caliber	6		30		GOMEX RC
	26		130		JAX RC
	128		640		Navy Cherry Point RC
	2		10		Northeast RC
	260		1,300		VACAPES RC
Gunnery Exercise Surface-to-Surface Boat Small-Caliber	67		335		GOMEX RC
	84		420		JAX RC
	92		460		Navy Cherry Point RC
	18		90		Northeast RC
	330		650		VACAPES RC
Gunnery Exercise Surface-to-Surface Ship Large-Caliber	10		50		Other AFTT Areas
	9		45		GOMEX RC
	51		255		JAX RC
	35		175		Navy Cherry Point RC
	75		375		VACAPES RC

Table 2.6-1: Proposed Training Activities per Alternative (continued)

Activity Name	Annual # of Activities[a]		5-Year # of Activities		Location[b]
	Alt 1	Alt 2	Alt 1	Alt 2	
Gunnery Exercise Surface-to-Surface Ship Medium-Caliber	41		205		Other AFTT Areas
	33		165		GOMEX RC
	161		805		JAX RC
	72		360		Navy Cherry Point RC
	321		1,605		VACAPES RC
Gunnery Exercise Surface-to-Surface Ship Small-Caliber	50		250		Other AFTT Areas
	10		50		GOMEX RC
	300		1,500		JAX RC
	20		100		Navy Cherry Point RC
	450		2,250		VACAPES RC
Integrated Live Fire Exercise	2		10		JAX RC
	2		10		VACAPES RC
Laser Targeting – Aircraft	315		1,575		JAX RC
	272		1,360		VACAPES RC
Laser Targeting – Ship	4		20		JAX RC
	4		20		VACAPES RC
Maritime Security Operations	59		245		GOMEX RC
	210		1,050		JAX RC
	75		375		Navy Cherry Point RC
	13		65		Northeast RC
	895		4,475		VACAPES RC
Missile Exercise Air-to-Surface	102		510		JAX RC
	52		260		Navy Cherry Point RC
	88		440		VACAPES RC
Missile Exercise Air-to-Surface – Rocket	10		50		GOMEX RC
	102		510		JAX RC
	10		50		Navy Cherry Point RC
	92		460		VACAPES RC
Missile Exercise Surface-to-Surface	16		80		JAX RC
	12		60		VACAPES 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		GOMEX RC
	231		1,155		JAX RC
	710		3,550		VACAPES RC
Search and Rescue	776		3,880		JAX RC
	1,176		5,880		VACAPES 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

Table 2.6-1: Proposed Training Activities per Alternative (continued)

Activity Name	Annual # of Activities[a] Alt 1	Annual # of Activities[a] Alt 2	5-Year # of Activities Alt 1	5-Year # of Activities Alt 2	Location[b]
Submarine Sonar Maintenance	12		60		Other AFTT Areas
	66		330		NSB New London
	9		45		JAX 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		VACAPES RC
Submarine Under Ice Certification	3		15		JAX RC
	3		15		Navy Cherry Point RC
	9		45		Northeast RC
	9		45		VACAPES RC
Surface Ship Object Detection	76		380		NS Mayport
	162		810		NS Norfolk
Surface Ship Sonar Maintenance	0	18	0	90	Other AFTT Areas
	0	18	0	90	JAX RC
	50		250		NS Mayport
	120		600		Navy Cherry Point RC
	235		1,175		NS Norfolk
	120		600		VACAPES RC
Waterborne Training	42		210		GOMEX RC
	55		275		JAX RC
	141		705		Northeast RC
	110		550		VACAPES RC

[a] 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.

[b] Locations given are areas where activities typically occur. However, activities could be conducted in other locations within the Study 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.

[c] For anti-submarine warfare tracking exercise – Ship, Alternative 1, 50 percent of requirements are met through synthetic training or other training exercises.

[1] Other AFTT Areas include areas outside of range complexes and testing ranges but still within the AFTT Study Area. Other AFTT Area activities typically refer to those activities that occur while vessels are in transit.

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

2.6.2 Proposed Testing Activities

All proposed testing activities are listed in Table 2.6-2 through Table 2.6-4.

Table 2.6-2: Naval Air Systems Command Proposed Testing Activities per Alternative

Activity Name	*Annual # of Activities[1]*		*5-Year # of Activities*		*Location[2]*
	Alt 1	*Alt 2*	*Alt 1*	*Alt 2*	
Air Warfare					
Air Combat Maneuver Test	550		2,750		VACAPES RC
Air Platform Weapons Integration Test	40		200		VACAPES RC
Air Platform-Vehicle Test	12		60		GOMEX RC
	9		45		JAX RC
	9		45		Key West RC
	9		45		Navy Cherry Point RC
	190		950		VACAPES RC
Air-to-Air Weapons System Test	10		50		GOMEX RC
Air-to-Air Gunnery Test – Medium-Caliber	55		275		VACAPES RC
Air-to-Air Missile Test	83		415		VACAPES RC
Intelligence, Surveillance, and Reconnaissance Test	7		35		JAX RC
	9		45		Navy Cherry Point RC
	406		2,030		VACAPES RC
Anti-Submarine Warfare					
Anti-Submarine Warfare Torpedo Test	20–43	43	146	215	JAX RC
	40–121	121	362	605	VACAPES RC
Anti-Submarine Warfare Tracking Test – Helicopter	4–6	6	24	30	GOMEX RC
	0–12	12	24	60	JAX RC
	2–27	26-27	35	131	Key West RC
	28–110	110	304	550	Northeast RC
	137–280	280	951	1,400	VACAPES RC
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft	10–15	15	60	75	GOMEX RC
	19	24	95	120	JAX RC
	10–12	12	54	60	Key West RC
	14–15	16	72	80	Navy Cherry Point RC
	36–45	48	198	240	Northeast RC
	25	26	125	130	VACAPES RC
Kilo Dip	2–6	6	14	30	GOMEX RC
	0–6	6	6	30	JAX RC
	0–6	6	6	30	Key West RC
	0–4	4	8	20	Northeast RC
	20–40	40	140	200	VACAPES RC
Sonobuoy Lot Acceptance Test	160		800		Key West RC

Table 2.6-2: Naval Air Systems Command Proposed Testing Activities per Alternative (continued)

Activity Name	Annual # of Activities[1] Alt 1	Annual # of Activities[1] Alt 2	5-Year # of Activities Alt 1	5-Year # of Activities Alt 2	Location[2]
Electronic Warfare					
Chaff Test	20		100		GOMEX RC
	4		20		JAX RC
	24		120		VACAPES RC
Electronic Systems Evaluation	2		10		JAX RC
	61		305		VACAPES RC
Flare Test	10		50		GOMEX RC
	20		100		VACAPES RC
Mine Warfare					
Airborne Dipping Sonar Minehunting Test	16–32	32	96	160	NSWC Panama City
	6–18	18	42	90	VACAPES RC
Airborne Laser Based Mine Detection System Test	40		200		NSWC Panama City
	50		250		VACAPES RC
Airborne Mine Neutralization System Test	20–27	32	107	160	NSWC Panama City
	25–45	50	145	250	VACAPES RC
Airborne Sonobuoy Minehunting Test	52		260		NSWC Panama City
	24		120		VACAPES RC
Mine Laying Test	1		5		JAX RC
	2		10		VACAPES RC
Surface Warfare					
Air-to-Surface Bombing Test	20		100		VACAPES RC
Air-to-Surface Gunnery Test	25–55	55	215	275	JAX RC
	110–140	140	640	700	VACAPES RC
Air-to-Surface Missile Test	0–10	10	20	50	GOMEX RC
	29–38	38	167	190	JAX RC
	117–148	148	663	740	VACAPES RC
High-Energy Laser Weapons Test	108		540		VACAPES RC
Laser Targeting Test	5		25		VACAPES RC
Rocket Test	15–19	19	87	95	JAX RC
	31–35	35	167	175	VACAPES RC
Other Testing Activities					
Undersea Range System Test	4–20		42		JAX RC
Acoustic and Oceanographic Research	1		5		GOMEX RC
	1		5		JAX RC
	1		5		Key West RC
	1		5		Northeast RC
	1		5		VACAPES RC

Table 2.6-2: Naval Air Systems Command Proposed Testing Activities per Alternative (continued)

Activity Name	Annual # of Activities[1]		5-Year # of Activities		Location[2]
	Alt 1	Alt 2	Alt 1	Alt 2	
Air Platform Shipboard Integrate Test	126		630		VACAPES RC
Maritime Security	12		60		JAX RC
	12		60		Navy Cherry Point RC
	20		100		VACAPES RC
Shipboard Electronic Systems Evaluation	24		120		GOMEX RC
	24		120		JAX RC
	24		120		Key West RC
	26		130		VACAPES 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 Study Area.

Notes: Alt: Alternative; GOMEX: Gulf of Mexico; JAX: Jacksonville; NSWC: Naval Surface Warfare Center; RC: Range Complex; VACAPES: Virginia Capes

Table 2.6-3: Naval Sea Systems Command Proposed Testing Activities per Alternative

<table>
<tr><th rowspan="2">Activity Name</th><th colspan="2">Annual # of Activities[1]</th><th colspan="2">5-Year # of Activities</th><th rowspan="2">Location[2]</th></tr>
<tr><th>Alt 1</th><th>Alt 2</th><th>Alt 1</th><th>Alt 2</th></tr>
<tr><td colspan="6">Anti-Submarine Warfare</td></tr>
<tr><td rowspan="4">Anti-Submarine Warfare Mission Package Testing</td><td colspan="2">42</td><td colspan="2">210</td><td>JAX RC</td></tr>
<tr><td colspan="2">4</td><td colspan="2">20</td><td>Newport, RI</td></tr>
<tr><td colspan="2">4</td><td colspan="2">20</td><td>NUWC Newport</td></tr>
<tr><td colspan="2">26</td><td colspan="2">130</td><td>VACAPES RC</td></tr>
<tr><td rowspan="7">At-Sea Sonar Testing</td><td colspan="2">2</td><td colspan="2">10</td><td>JAX RC
Navy Cherry Point RC
Northeast RC
VACAPES RC</td></tr>
<tr><td colspan="2">1</td><td colspan="2">5</td><td>JAX RC
Navy Cherry Point RC
VACAPES RC</td></tr>
<tr><td colspan="2">2</td><td colspan="2">10</td><td>Offshore Fort Pierce, FL
GOMEX RC
JAX RC
SFOMF
Northeast RC
VACAPES</td></tr>
<tr><td colspan="2">4</td><td colspan="2">20</td><td>JAX RC</td></tr>
<tr><td colspan="2">2</td><td colspan="2">10</td><td>Navy Cherry Point RC</td></tr>
<tr><td colspan="2">8</td><td colspan="2">40</td><td>NUWC Newport</td></tr>
<tr><td colspan="2">12</td><td colspan="2">60</td><td>VACAPES RC</td></tr>
<tr><td rowspan="2">Countermeasure Testing</td><td colspan="2">5</td><td colspan="2">25</td><td>GOMEX RC
Key West RC
JAX RC
NUWC Newport
VACAPES RC</td></tr>
<tr><td colspan="2">2–4</td><td colspan="2">14</td><td>GOMEX RC
JAX RC
Northeast RC
VACAPES RC</td></tr>
<tr><td rowspan="9">Pierside Sonar Testing</td><td colspan="2">1</td><td colspan="2">5</td><td>NSB New London
NS Norfolk
Port Canaveral, FL</td></tr>
<tr><td colspan="2">11</td><td colspan="2">55</td><td>Bath, ME</td></tr>
<tr><td colspan="2">5</td><td colspan="2">25</td><td>NSB New London</td></tr>
<tr><td colspan="2">4</td><td colspan="2">20</td><td>NSB Kings Bay</td></tr>
<tr><td colspan="2">8</td><td colspan="2">40</td><td>Newport, RI</td></tr>
<tr><td colspan="2">13</td><td colspan="2">65</td><td>NS Norfolk</td></tr>
<tr><td colspan="2">2</td><td colspan="2">10</td><td>Pascagoula, MS</td></tr>
<tr><td colspan="2">3</td><td colspan="2">15</td><td>Port Canaveral, FL</td></tr>
<tr><td colspan="2">2</td><td colspan="2">10</td><td>PNS</td></tr>
<tr><td rowspan="2">Submarine Sonar Testing/Maintenance</td><td colspan="2">16</td><td colspan="2">80</td><td>Norfolk, VA</td></tr>
<tr><td colspan="2">24</td><td colspan="2">120</td><td>PNS</td></tr>
</table>

Table 2.6-3: Naval Sea Systems Command Proposed Testing Activities per Alternative (continued)

Activity Name	Annual # of Activities[1]		5-Year # of Activities		Location[2]
	Alt 1	Alt 2	Alt 1	Alt 2	
Surface Ship Sonar Testing/Maintenance	1		5		JAX RC
	1		5		NS Mayport
	3		15		NS Norfolk
	3		15		VACAPES RC
Torpedo (Explosive) Testing	4		20		GOMEX RC Offshore Fort Pierce, FL Key West RC Navy Cherry Point RC Northeast RC VACAPES RC
	2		10		GOMEX RC JAX RC Northeast RC VACAPES RC
Torpedo (Non-Explosive) Testing	7		35		GOMEX RC
	11		55		Offshore Fort Pierce, FL
	2		8		JAX RC
	7		35		Navy Cherry Point RC
	8		38		Northeast RC
	30		150		NUWC Newport
	11		55		VACAPES RC
Electronic Warfare					
Radar and Other System Testing	6–10		34		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC NSWC Panama City NUWC Newport SFOMF VACAPES RC
	4		20		NSB New London
	0–3		3		JEB LC-FS NS Norfolk
	2		10		NS Norfolk
	2		10		Northeast RC
	21–45		129		VACAPES RC
Mine Warfare					
Mine Countermeasure and Neutralization Testing	13		65		NSWC Panama City
	6		30		VACAPES RC
Mine Countermeasure Mission Package Testing	19		95		GOMEX RC
	10		50		JAX RC
	11		55		NSWC Panama City
	2		10		SFOMF
	5		25		VACAPES RC

Table 2.6-3: Naval Sea Systems Command Proposed Testing Activities per Alternative (continued)

Activity Name	Annual # of Activities[1]		5-Year # of Activities		Location[2]
	Alt 1	Alt 2	Alt 1	Alt 2	
Mine Detection and Classification Testing	6		30		GOMEX RC
	10		50		Navy Cherry Point RC
	47–55		250		NSWC Panama City
	7–12		43		Riviera Beach, FL
	4		20		SFOMF
	3		15		VACAPES RC
Surface Warfare					
Gun Testing – Large-Caliber	12		60		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC VACAPES RC
	1		5		GOMEX RC
	1		5		JAX RC
	1		5		Key West RC
	1		5		Navy Cherry Point RC
	1		5		Northeast RC
	33		165		NSWC Panama City
	5		25		VACAPES RC
Gun Testing – Medium-Caliber	12		60		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC VACAPES RC
	102		510		NSWC Panama City
	5		24		VACAPES RC
Gun Testing – Small-Caliber	24		120		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC VACAPES RC
	13		65		GOMEX RC
	7		35		NSWC Panama City
	8		40		VACAPES RC
Kinetic Energy Weapon Testing	61		301		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC VACAPES RC

Table 2.6-3: Naval Sea Systems Command Proposed Testing Activities per Alternative (continued)

Activity Name	Annual # of Activities[1]		5-Year # of Activities		Location[2]
	Alt 1	Alt 2	Alt 1	Alt 2	
Missile and Rocket Testing	13		65		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC VACAPES RC
	1		5		GOMEX RC
	2		10		JAX RC
	5		25		Northeast RC
	22		110		VACAPES RC
Unmanned Systems					
Underwater Search, Deployment, and Recovery	33		165		SFOMF
Unmanned Aerial System Testing	15		75		Northeast RC
	17		85		NUWC Newport
	15		75		VACAPES RC
Unmanned Surface Vehicle System Testing	132		660		NUWC Newport
Unmanned Underwater Vehicle Testing	16		80		GOMEX RC JAX RC NUWC Newport
	41		205		GOMEX RC
	25		125		JAX 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		VACAPES RC
Air Defense Testing	1		5		GOMEX RC
	2		10		JAX RC
	1		5		Northeast RC
	5		25		VACAPES RC
Hydrodynamic and Maneuverability Testing	2		10		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC VACAPES RC
In-Port Maintenance Testing	24		120		NS Mayport NS Norfolk
	2		10		NS Mayport
	5		25		NS Norfolk

Table 2.6-3: Naval Sea Systems Command Proposed Testing Activities per Alternative (continued)

Activity Name	Annual # of Activities[1] Alt 1	Annual # of Activities[1] Alt 2	5-Year # of Activities Alt 1	5-Year # of Activities Alt 2	Location[2]
Large Ship Shock Trial	0-1		1		GOMEX RC JAX RC VACAPES RC
Propulsion Testing	34		170		GOMEX RC JAX RC Key West RC Navy Cherry Point RC Northeast RC VACAPES RC
	86		430		Gulf of Mexico
	2		10		JAX RC
	6		30		Navy Cherry Point RC
	5		25		Northeast RC
	7		35		VACAPES RC
Signature Analysis Operations	1		5		JAX RC
	59		295		SFOMF
Small Ship Shock Trial	0–3		3		JAX RC VACAPES RC
Surface Warfare Testing	2		10		GOMEX RC
	13		65		JAX RC
	1		5		Key West RC
	10		50		Northeast RC
	9		45		VACAPES RC
Submarine Sea Trials – Propulsion Testing	1		5		JAX RC
	1		5		Northeast RC
	1		5		VACAPES RC
Submarine Sea Trials – Weapons System Testing	2		10		Offshore Fort Pierce, FL GOMEX RC JAX RC SFOMF Northeast RC VACAPES RC
	4		20		JAX RC
	4		20		Northeast RC
	4		20		VACAPES RC
Total Ship Survivability Trials	0–1		1		JAX RC VACAPES RC
Undersea Warfare Testing	2		10		JAX RC VACAPES RC
	0–2		4		JAX RC Navy Cherry Point RC SFOMF VACAPES RC
	2		10		GOMEX RC
	6		30		JAX RC
	2		10		VACAPES RC

Table 2.6-3: Naval Sea Systems Command Proposed Testing Activities per Alternative (continued)

Activity Name	Annual # of Activities[1]		5-Year # of Activities		Location[2]
	Alt 1	Alt 2	Alt 1	Alt 2	
Vessel Signature Evaluation	9		45		JAX RC VACAPES RC
	2		10		GOMEX RC
	16		80		JAX RC
	5		25		JEB LC-FS
	18		90		VACAPES 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		JAX RC
	80		400		Navy Cherry Point RC
	80		400		Northeast RC
	80		400		VACAPES RC
Non-Acoustic Component Testing	4		20		GOMEX RC
	4		20		VACAPES RC
Payload Deployer Testing	1		5		GOMEX 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

[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 Study 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: Alt: Alternative; GOMEX: Gulf of Mexico; JAX: Jacksonville; JEB LC-FS: Joint Expeditionary Base Little Creek-Fort Story; 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; VACAPES: Virginia Capes

Table 2.6-4: Office of Naval Research Proposed Testing Activities per Alternative

<table>
<tr><th rowspan="2">Activity Name</th><th colspan="2">Annual # of Activities</th><th colspan="2">5-Year # of Activities</th><th rowspan="2">Location</th></tr>
<tr><th>Alt 1</th><th>Alt 2</th><th>Alt 1</th><th>Alt 2</th></tr>
<tr><th colspan="6">Acoustic and Oceanographic Science and Technology</th></tr>
<tr><td rowspan="4">Acoustic and Oceanographic Research</td><td colspan="2">5</td><td colspan="2">22</td><td>GOMEX RC</td></tr>
<tr><td colspan="2">9</td><td colspan="2">43</td><td>Northeast RC</td></tr>
<tr><td colspan="2">2</td><td colspan="2">10</td><td>Other AFTT Areas[1]</td></tr>
<tr><td colspan="2">2</td><td colspan="2">12</td><td>VACAPES RC</td></tr>
<tr><td rowspan="3">Emerging Mine Countermeasure Technology Research</td><td colspan="2">1</td><td colspan="2">5</td><td>JAX RC</td></tr>
<tr><td colspan="2">2</td><td colspan="2">12</td><td>Northeast RC</td></tr>
<tr><td colspan="2">1</td><td colspan="2">5</td><td>VACAPES RC</td></tr>
<tr><td rowspan="5">Large Displacement Unmanned Underwater Vehicle Testing</td><td colspan="2">4</td><td colspan="2">20</td><td>GOMEX RC</td></tr>
<tr><td colspan="2">12</td><td colspan="2">60</td><td>JAX RC</td></tr>
<tr><td colspan="2">4</td><td colspan="2">20</td><td>Navy Cherry Point RC</td></tr>
<tr><td colspan="2">16</td><td colspan="2">80</td><td>Northeast RC</td></tr>
<tr><td colspan="2">8</td><td colspan="2">40</td><td>VACAPES RC</td></tr>
</table>

[1] Other AFTT Areas include areas outside of range complexes and testing ranges but still within the AFTT Study Area. Other AFTT Area activities typically refer to those activities that occur while vessels are in transit.

Notes: AFTT: Atlantic Fleet Training and Testing; Alt: Alternative; GOMEX: Gulf of Mexico; JAX: Jacksonville, Florida; RC: Range Complex; VACAPES: Virginia Capes

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

TABLE OF CONTENTS

List of Figures

List of Tables

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3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.0 INTRODUCTION

This chapter describes existing environmental conditions in the Atlantic Fleet Training and Testing (AFTT) Study Area as well as the analysis of resources potentially impacted by the Proposed Action described in Chapter 2 (Description of Proposed Action and Alternatives). The Study Area is described in Section 2.1 (Description of the Atlantic Fleet Training and Testing Study Area) and depicted in Figure 2.1-1.

This section provides the ecological characterization of the Study Area and describes the resources evaluated in the analysis. The Overall Approach to Analysis section explains that each proposed military readiness activity was examined to determine which environmental stressors could potentially impact a resource.

Resources Analyzed:
Physical Resources:
- Air Quality
- Sediments and Water Quality

Biological Resources:
- Vegetation
- Invertebrates
- Habitats
- Fishes
- Marine Mammals
- Reptiles
- Birds and Bats

Human Resources:
- Cultural Resources
- Socioeconomic Resources
- Public Health and Safety

The sections following 3.0 (Introduction) provide analyses for each resource. The physical resources (air quality, and sediments and water quality) are presented first (Sections 3.1 and 3.2, respectively). Because impacts to air or water quality could affect all other marine resources, any potential impacts on air quality or sediments and water quality were considered as potential secondary stressors on the remaining resources to be described: vegetation, invertebrates, habitats, fishes, marine mammals, reptiles, and birds and bats (Sections 3.3 through 3.9). Following the biological resource sections are human resource sections: cultural resources, socioeconomic resources, and public health and safety (Sections 3.10, 3.11, and 3.12).

3.0.1 NAVY COMPILED AND GENERATED DATA

While preparing this document, the United States (U.S.) Department of the Navy (Navy) used the best available data, science, and information accepted by the relevant and appropriate regulatory and scientific communities to establish a baseline and perform environmental analyses for all resources in accordance with National Environmental Policy Act (NEPA), the Administrative Procedure Act (5 United States Code sections 551–596), and Executive Order 12114.

In support of the environmental baseline and environmental consequences sections for this and other environmental documents, the Navy has sponsored and supported both internal and independent research and monitoring efforts. The Navy's research and monitoring programs, as described below, are largely focused on filling data gaps and obtaining the most up-to-date science.

3.0.1.1 Marine Species Monitoring and Research Programs

The Navy has been conducting marine species monitoring for compliance with the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) since 2006, both in association with training and testing events and independently. In addition to monitoring activities associated with regulatory compliance, two other Navy research programs provide extensive investments in basic and applied research: the Office of Naval Research Marine Mammals & Biology program, and the Living Marine Resources program. In fact, the U.S. Navy is one of the largest sources of funding for marine mammal research in the world. A survey of federally-funded marine mammal research and conservation conducted by the Marine Mammal Commission found that the U.S. Department of Navy was the second largest source of funding for marine mammal activities (direct project expenditures, as well as associated indirect or support costs) in the United States in 2014, second only to National Oceanic and Atmospheric Administration Fisheries (Purdy, 2016).

The monitoring program has historically focused on collecting baseline data that supports analysis of marine mammal occurrence, distribution, abundance, and habitat use preferences in and around ocean areas in the Atlantic and Pacific where the Navy conducts training and testing. More recently, the priority has begun to shift towards assessing the potential response of individual species to training and testing activities. Data collected through the monitoring program serves to inform the analysis of impacts on marine mammals with respect to species distribution, habitat use, and potential responses to training and testing activities. Monitoring is performed using various methods, including visual surveys from surface vessels and aircraft, passive acoustics, and tagging. Additional information on the program is available on the U.S. Navy Marine Species Monitoring Program website, https://www.navymarinespeciesmonitoring.us/, which serves as a public online portal for information on the background, history, and progress of the program and also provides access to reports, documentation, data, and updates on current monitoring projects and initiatives.

The two other Navy programs previously mentioned invest in research on the potential effects of sound on marine species and develop scientific information and analytic tools that support preparation of environmental impact statements (EISs) and associated regulatory processes under the MMPA and ESA, as well as support development of improved monitoring and detection technology and advance overall knowledge about marine species. These programs support coordinated science, technology, research, and development focused on understanding the effects of sound on marine mammals and other marine species, including physiological, behavioral, ecological, and population-level effects.[1] Additional information on these programs and other ocean resources-oriented initiatives can be found at the U.S. Navy Green Fleet – Energy, Environment, and Climate Change website.

3.0.1.2 Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals

If proposed Navy activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts on marine species is conducted. Data on the density of animals (number of animals per unit area) of each species and stock is needed, along with criteria and thresholds defining the levels of sound and energy that may cause certain types of impacts. The Navy's acoustic effects model takes the density and the criteria and thresholds as inputs and analyzes Navy training and testing activities. Finally, mitigation and animal avoidance behaviors are considered to determine the number of impacts that could occur. The inputs and process are described below. A detailed explanation of this analysis is provided in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea*

[1] A population-level impact is an impact on the population numbers (survival) or growth and reproductive rates (recruitment) of a particular marine mammal species or stock.

Turtles: Methods and Analytical Approach for Phase III Training and Testing (U.S. Department of the Navy, 2018b).

3.0.1.2.1 Marine Species Density Database

A quantitative analysis of impacts on a species requires data on their abundance and distribution in the potentially impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area. Estimating marine species density requires substantial surveys and effort to collect and analyze data to produce a usable estimate. The National Marine Fisheries Service (NMFS) is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. Exclusive Economic Zone. Other agencies and independent researchers often publish density data for species in specific areas of interest, including areas outside the U.S. Exclusive Economic Zone. In areas where surveys have not produced adequate data to allow robust density estimates, methods such as model extrapolation from surveyed areas, Relative Environmental Suitability models, or expert opinion are used to estimate occurrence. These density estimation methods rely on information such as animal sightings from adjacent locations, amount of survey effort, and the associated environmental variables (e.g., depth, sea surface temperature).

There is no single source of density data for every area of the world, species, and season because of the fiscal limitations, resources, effort involved in providing survey coverage to sufficiently estimate density, and practical limitations. Therefore, to characterize marine species density for large areas, such as the AFTT Study Area, the Navy compiled data from multiple sources and developed a protocol to select the best available density estimates based on species, area, and time (i.e., season). When multiple data sources were available, the Navy ranked density estimates based on a hierarchal approach to ensure that the most accurate estimates were selected. The highest tier included peer-reviewed published studies of density estimates from spatial models since these provide spatially-explicit density estimates with relatively low uncertainty. Other preferred sources included peer reviewed published studies of density estimates derived from systematic line-transect survey data, the method typically used for the NMFS marine mammal stock assessment reports. In the absence of survey data, information on species occurrence and known or inferred habitat associations have been used to predict densities using model-based approaches including Relative Environmental Suitability models. Because these estimates inherently include a high degree of uncertainty, they were considered the least preferred data source. In cases where a preferred data source was not available, density estimates were selected based on expert opinion from scientists.

The resulting Geographic Information System database includes seasonal density values for every marine mammal and sea turtle species present within the Study 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 Study Area (U.S. Department of the Navy, 2017b), hereafter referred to as the Density Technical Report. These data are used as an input into the Navy Acoustic Effects Model.

The Density Technical Report describes the density models that were utilized in detail and provides detailed explanations of the models applied to each species density estimate. The below list describes models in order of preference.

1. Spatial density models are preferred and used when available because they provide an estimate with the least amount of uncertainty by deriving estimates for divided segments of the sampling area. These models (see Becker et al., 2016; Forney et al., 2015) predict spatial variability of animal presence as a function of 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.

2. Stratified design-based density estimates use line-transect survey data with the sampling area divided (stratified) into sub-regions, and a density is predicted for each sub-region (Barlow, 2016; Becker et al., 2016; Bradford et al., 2017; Campbell et al., 2015; Jefferson et al., 2014). While geographically stratified density estimates provide a better indication of a species' distribution within the Study Area, the uncertainty is typically high because each sub-region estimate is based on a smaller stratified segment of the overall survey effort.
3. Design-based density estimations use line-transect survey data from land and aerial surveys designed to cover a specific geographic area (see Carretta et al., 2015). These estimates use the same survey data as stratified design-based estimates, but are not segmented into sub-regions and instead provide one estimate for a large surveyed area.
4. Although relative environmental suitability models provide estimates for areas of the oceans that have not been surveyed using information on species occurrence and inferred habitat associations and have been used in past density databases, these models were not used in the current quantitative analysis.

When interpreting the results of the quantitative analysis, as described in the Density Technical Report, it is important to consider that "each model is limited to the variables and assumptions considered by the original data source provider. No mathematical model representation of any biological population is perfect, and with regards to marine mammal biodiversity, any single model will not completely explain the results" (U.S. Department of the Navy, 2017b). These factors and others described in the Density Technical Report should be considered when examining the estimated impact numbers in comparison to current population abundance information for any given species or stock.

3.0.1.2.2 Developing Acoustic and Explosive Criteria and Thresholds

Information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed to analyze potential impacts to marine species. Revised Phase III criteria and thresholds for quantitative modeling of impacts use the best available existing data from scientific journals, technical reports, and monitoring reports to develop thresholds and functions for estimating impacts on marine species. Working with NMFS, the Navy has developed updated criteria for marine mammals and sea turtles. Criteria for estimating impacts on marine fishes are also used in this analysis, which largely follow the *Sound Exposure Guidelines for Fishes and Sea Turtles* (Popper et al., 2014).

Since the release of the Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effect Analysis in 2012 (U.S. Department of the Navy, 2012c), recent and emerging science has necessitated an update to these criteria and thresholds for assessing potential impacts on marine mammals and sea turtles. A detailed description of the Phase III acoustic and explosive criteria and threshold development is included in the supporting technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III) (U.S. Department of the Navy, 2017a)* and details are provided in each resource section. A series of behavioral studies, largely funded by the U.S. Navy, has led to a new understanding of how some species of marine mammals react to military sonar. This resulted in developing new behavioral response functions for estimating alterations in behavior. Additional information on auditory weighting functions has also emerged [e.g.,Mulsow et al. (2015)] leading to developing a new methodology to predict auditory weighting functions for each hearing group along with the accompanying hearing loss thresholds. These criteria for predicting hearing loss in marine mammals were largely adopted by NMFS for species within their purview (National Marine Fisheries Service, 2016)).

The Navy also uses criteria for estimating effects to fishes and the ranges to which those effects are likely to occur. A working group of experts generated a technical report that provides numerical criteria and relative likelihood of effects to fish within different hearing groups (i.e., fishes with no swim bladder versus fishes with a swim bladder involved in hearing) (Popper et al., 2014). Where applicable, thresholds and relative risk factors presented in the technical report were used to assist in the analysis of effects to fishes from Navy activities. Details on criteria used to estimate impacts on marine fishes are contained within the appropriate stressor section (e.g., sonar and other transducers, explosives) within Section 3.6 (Fishes). This panel of experts also estimated parametric criteria for the effects of sea turtle exposure to sources located at 'near,' 'intermediate,' and 'far' distances, assigning 'low,' 'medium,' and 'high' probability to specific categories of behavioral impacts (Popper et al., 2014).

3.0.1.2.3 The Navy's Acoustic Effects Model

The Navy's Acoustic Effects Model calculates sound energy propagation from sonar and other transducers, air guns, and explosives during naval activities and the energy or sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals or sea turtles distributed in the area around the modeled naval activity that each animat records its individual sound "dose." The model bases the distribution of animats over the Study Area on the density values in the Navy Marine Species Density Database and distributes animats in the water column proportional to the known time that species spend at varying depths.

The model accounts for environmental variability of sound propagation in both distance and depth when computing the received sound level on the animats. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animals. The number of animats that exceed the received threshold for an effect is tallied to provide an estimate of the number of marine mammals or sea turtles that could be affected.

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 modeled) and without any avoidance of the activity by the animal. The final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation. For sonar and other transducers, the possibility that marine mammals or sea turtles would avoid continued or repeated sound exposures is also considered.
- Many explosions from munitions such as bombs and missiles actually occur upon impact with above-water targets and at the water's surface. However, for this analysis, sources such as these were modeled as exploding underwater. This overestimates the amount of explosive and acoustic energy entering the water.

The model estimates the impacts caused by individual training and testing activities. 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 that marine mammals or sea turtles may be exposed to sound levels resulting in an effect. Therefore, the model estimates the number of instances in which an effect threshold was 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 (i.e., some marine mammals or sea turtles could be impacted several times, while others would not experience any impact). A detailed explanation of the Navy's Acoustic Effects Model is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

3.0.1.2.4 Accounting for Mitigation

3.0.1.2.4.1 Sonar and Other Transducers

The Navy implements mitigation measures (described in Section 2.3.4, Mitigation Measures) during activities that use sonar and other transducers, including the power-down or shut-down (i.e., power-off) of sonar when a marine mammal is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to injury (including permanent threshold shift [PTS]) for a given sonar exposure. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

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 temporary threshold shift (TTS). The quantitative analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

The ability to observe the range to PTS was estimated for each training or testing event. The ability of Navy Lookouts to detect marine mammals or sea turtles in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as 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 and Cuvier's beaked whales (Baird, 2013) and Blainville's beaked whales (HDR, 2012) were occasionally observed breaching. These behaviors are visible from a great distance and likely increase sighting distances and detections of these species. 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.

3.0.1.2.4.2 Explosions

The Navy implements mitigation measures (described in Section 5.3, Procedural Mitigation to be Implemented) during explosive activities, including delaying detonations when a marine mammal is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to mortality for a given explosive. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of mortality due to exposure to explosives. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., gunnery exercise) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

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

3.0.1.2.5 Marine Mammal Avoidance of Sonar and other Transducers

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

3.0.1.3 Aquatic Habitats Database

The AFTT and Hawaii-Southern California Training and Testing Aquatic Habitat Database was developed after the completion of the 2013 AFTT and Hawaii-Southern California Training and Testing EIS/Overseas Environmental Impact Statement (OEIS) in order to refine the regional scale and overlapping habitat data used in the analysis of military expended materials and bottom explosives. The database includes more numerous data sources ranging from regional-to-local scale. These data sources are subsequently combined to create a non-overlapping mosaic of habitat information that presents the highest quality data for a given location. The database primarily includes areas within the Study Area; however, there are also specific point locations for selected habitat types (e.g., artificial substrate). The current database is limited to abiotic (physical rather than biological) substrate types assessed in Section 3.5 (Habitats) for the current AFTT and Hawaii-Southern California Training and Testing EIS documents. A detailed description of the database is included as a supporting technical document with associated Geographic Information System and database deliverables (U.S. Department of the Navy, 2018a).

3.0.2 Ecological Characterization of the Study Area

The Study Area includes the intertidal and subtidal marine waters within the boundaries shown in Figure 2.1-1 but does not extend above the mean high tide line. Navy activities in the marine environment predominately occur within established operating areas (OPAREAs), range complexes, testing ranges, ports, and pierside locations. These locations are determined by Navy requirements, with locations set so as not to interfere with existing civilian and commercial maritime and airspace boundaries. The Navy-defined boundaries are not consistent with ecological boundaries, such as ecosystems, that may be more appropriate when assessing potential impacts on marine resources. Therefore, for the purposes of this document, the Navy analyzed the marine resources in an ecological context to the extent possible to more comprehensively assess the potential impacts. The Navy used biogeographic classification systems to frame this ecological context.

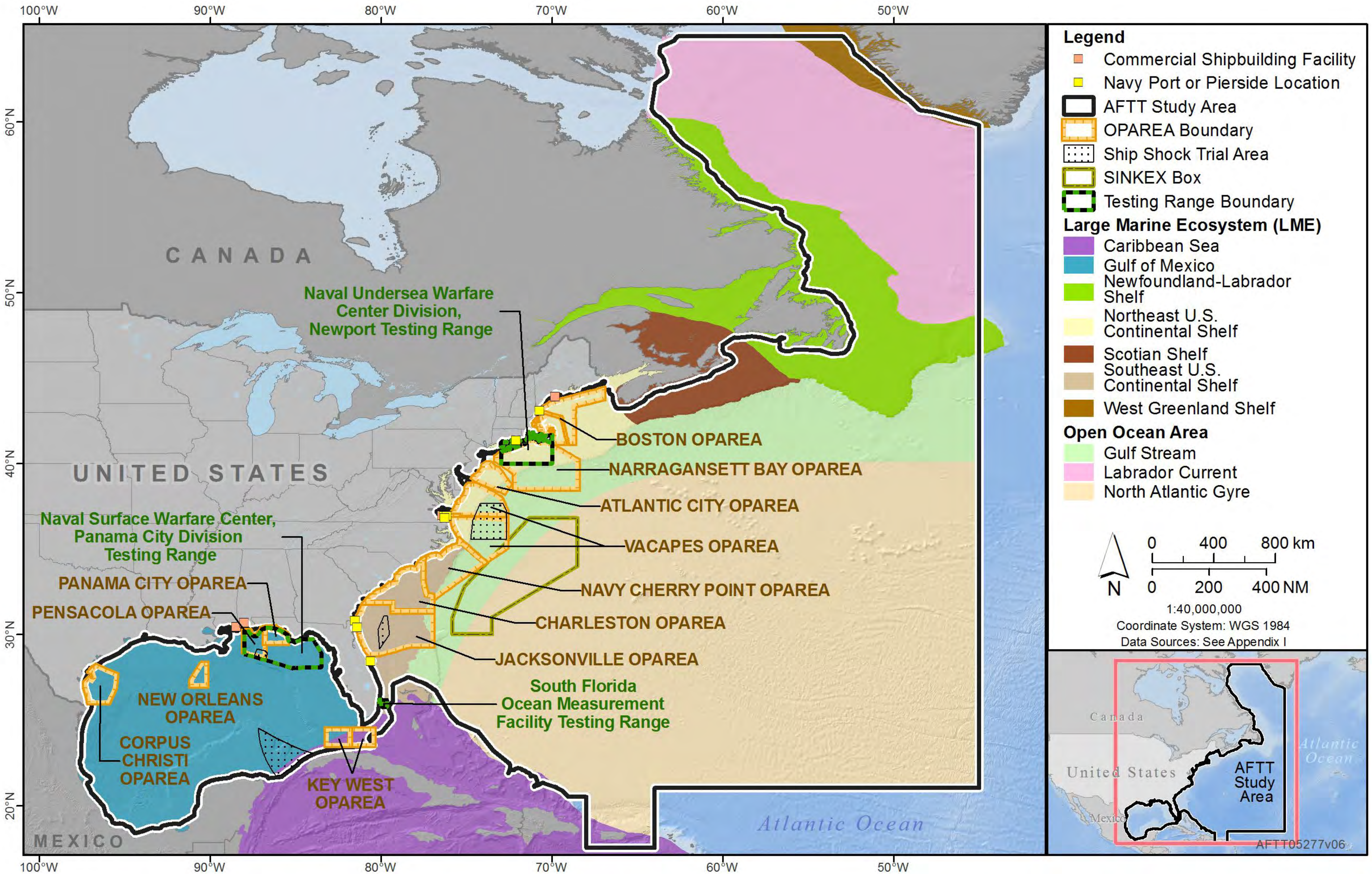
Biogeographic classifications organize and describe the patterns and distributions of organisms and the biological and physical processes that influence this distribution. These biogeographic classification systems and areas are described in Section 3.0.2.1 (Biogeographic Classifications).

3.0.2.1 Biogeographic Classifications

For context, the Navy organized the resources within coastal waters by large marine ecosystems, where primary productivity is higher than open ocean areas (Sherman & Hempel, 2009). Primary productivity is the rate of the formation of organic material from inorganic carbon via photosynthesis (e.g., by marine vegetation) or chemical reactions. Resources within open ocean areas are characterized by main oceanographic features (currents, gyres).

The large marine ecosystem classification system originated in the mid-1980s as a spatial planning tool to address transboundary management issues such as fisheries and pollution (Duda & Sherman, 2002). Large marine ecosystems are "relatively large areas of ocean space of approximately 200,000 square kilometers (km^2) or greater, adjacent to the continents in coastal waters where primary productivity is generally higher than in open ocean areas" (Duda & Sherman, 2002). The large marine ecosystem concept for ecosystem-based management includes a five-module approach: (1) productivity, (2) fish and fisheries, (3) pollution and ecosystem health, (4) socioeconomics, and (5) governance. This approach is being applied to 16 international projects in Africa, Asia, Latin America, and Eastern Europe (Duda & Sherman, 2002) as well as to the large marine ecosystems in the AFTT Study Area described in the sections below (Aquarone & Adams, 2009c).

The large marine ecosystem classification system was advocated by the Council on Environmental Quality's Interagency Ocean Policy Task Force (The White House Council on Environmental Quality, 2010) as a marine spatial framework for coordinating regional planning in the waters off of the United States. For this EIS/OEIS, three main oceanographic features are used: the Labrador Current, the Gulf Stream, and the North Atlantic Gyre. The Study Area contains seven designated large marine ecosystems: the West Greenland Shelf, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea. The seven large marine ecosystems and three open ocean areas are shown in Figure 3.0-1 and outlined in Sections 3.0.2.1.1 (West Greenland Shelf Large Marine Ecosystem) through 3.0.2.1.10 (North Atlantic Gyre Open Ocean Area). Designated training and testing areas in relation to each of the large marine ecosystems and open ocean areas are presented in Figure 3.0-1.



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

Figure 3.0-1: The Study Area with Large Marine Ecosystems and Open Ocean Areas

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3.0.2.1.1 West Greenland Shelf Large Marine Ecosystem

The West Greenland Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of 375,000 km^2 (Aquarone et al., 2009). No specifically designated training or testing areas fall within the West Greenland Shelf Large Marine Ecosystem; however, training may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities conducted outside of designated training and testing ranges, identified as "Other AFTT Areas." Examples of these activities include gunnery exercises and anti-submarine warfare tracking exercises. This large marine ecosystem extends off the west coast of Greenland adjacent to Baffin Bay and the Davis Strait. Most of this ecosystem extends outside the Study Area; only the southwestern portion occurs within the Study Area (Figure 3.0-1). Other oceanic influences on this area are the West Greenland Current Front and the East Greenland Current. Significant structural features of this ecosystem include the Fylass Bank and the Tasersuaq Estuary. Most of this large marine ecosystem is covered with ice during winter (Sherman & Hempel, 2009).

The West Greenland Shelf Large Marine Ecosystem provides resources for commercial fisheries (e.g., northern shrimp and flounder) and is an important feeding and migration area for the ESA-endangered Gulf of Maine Atlantic salmon (Fay et al., 2006). The average primary productivity within this large marine ecosystem is low: less than 150 grams (g) of carbon per square meter (m^2) per year (Aquarone et al., 2009). Low primary productivity is a result of low numbers of primary producers (e.g., algae) that are responsible for most of the primary production in the ocean and form the base of the marine food web. Refer to U.S. Department of the Navy (2012b) for more information. Less than 1 percent of the Study Area is in the West Greenland Shelf Large Marine Ecosystem.

3.0.2.1.2 Newfoundland-Labrador Shelf Large Marine Ecosystem

The Newfoundland-Labrador Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 896,000 km^2 (Aquarone & Adams, 2009b).

This large marine ecosystem extends off the east coast of Canada within the Labrador Current (Aquarone & Adams, 2009b). Other oceanic influences on this area are the Gulf Stream, Labrador Shelf-Slope Front, and Labrador Mid-Shelf Front. Important structural features of this ecosystem include a structurally complex seabed, 14 estuaries, and the Grand Banks, which is a rich fishing ground (Sherman & Hempel, 2009). The Newfoundland-Labrador Shelf Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., cod, haddock, and pollock). The average primary productivity within this large marine ecosystem is moderate: 150–300 g of carbon per m^2 per year (Aquarone & Adams, 2009b).

No specifically designated training or testing areas fall within the Newfoundland-Labrador Shelf Large Marine Ecosystem; however, training may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities conducted outside of designated training and testing ranges, identified as "Other AFTT Areas." Examples of these activities include gunnery exercises and anti-submarine warfare tracking exercises. Approximately 5 percent of the Study Area is located in the Newfoundland-Labrador Shelf Large Marine Ecosystem.

3.0.2.1.3 Scotian Shelf Large Marine Ecosystem

The Scotian Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 283,000 km^2 (Aquarone & Adams, 2009a). This large marine ecosystem is located off the coast of the Canadian province of Nova Scotia and extends to the shelf break (Aquarone & Adams, 2009a). The

Laurentian Channel in the north separates this large marine ecosystem from the Newfoundland-Labrador Shelf Large Marine Ecosystem. Oceanic influences in this area are the Gulf Stream, Nova Scotia Current, Cape North Front, Cabot Strait Front, Gully Front, and Shelf-Slope Front. Important structural features of this ecosystem include the St. Lawrence Estuary and the complex topography of the area, which includes deep, mid-shelf basins, and many off-shore shallow banks (Sherman & Hempel, 2009). The Scotian Shelf Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., cod, haddock, pollock, snow crab, northern shrimp, and short-finned squid). The average primary productivity within this large marine ecosystem is moderately high: 150–300 g of carbon per m^2 per year (Aquarone & Adams, 2009a).

No specifically designated training or testing areas fall within the Scotian Shelf Large Marine Ecosystem; however, training may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities conducted outside of designated training and testing ranges, identified as "Other AFTT Areas." Examples of these activities include gunnery exercises and anti-submarine warfare tracking exercises. Approximately 1 percent of the Study Area is located in the Scotian Shelf Large Marine Ecosystem.

3.0.2.1.4 Northeast United States Continental Shelf Large Marine Ecosystem

The Northeast U.S. Continental Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 310,000 km^2 (Aquarone & Adams, 2009c). This large marine ecosystem extends from the Gulf of Maine to Cape Hatteras, North Carolina. This area includes the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. For additional details on marine protected areas and national marine sanctuaries, see Section 6.1.2 (Marine Protected Areas).

Oceanic influences in this large marine ecosystem are the Gulf Stream, Cape North Front, Georges Bank Front, Maine Coastal Front, Mid-Shelf Front, Nantucket Shoals Front, and Shelf-Slope Front (Aquarone & Adams, 2009c). Important structural features of this ecosystem include 28 estuaries and river systems such as Penobscot Bay/River, Hudson River, Delaware Bay/River, and Chesapeake Bay (Sherman & Hempel, 2009). This large marine ecosystem also supplies an important ecosystem service by providing resources for commercial fisheries (e.g., cod, flounder, mackerel, lobster, sea scallops, and red crab). The Northeast U.S. Continental Shelf Large Marine Ecosystem is one of the most productive large marine ecosystems in the world, with a high average primary productivity of greater than 300 g of carbon per m^2 per year (Aquarone & Adams, 2009c).

A large proportion of Navy training and testing activities occur in the Northeast U.S. Continental Shelf Large Marine Ecosystem. To determine which designated training and testing areas (or portions of these areas) occur within this large marine ecosystem, refer to Figure 3.0-1, and for more information on the types of activities that will occur in range complexes within an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 2 percent of the Study Area is located in the Northeast U.S. Continental Shelf Large Marine Ecosystem.

3.0.2.1.5 Southeast United States Continental Shelf Large Marine Ecosystem

The Southeast U.S. Continental Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 300,000 km^2 (Aquarone, 2009). This large marine ecosystem extends from Cape Hatteras, North Carolina, to the Straits of Florida (Aquarone, 2009). This area includes the Monitor and Gray's Reef National Marine Sanctuaries. For additional details on marine protected areas and national marine sanctuaries, see Section 6.1.2 (Marine Protected Areas).

Oceanic influences in this large marine ecosystem are the Gulf Stream, Inshore Gulf Stream Front, Mid-Shelf Front, and Offshore Gulf Stream Front. Important structural features of this ecosystem include many types of habitat such as coral reefs, estuaries, barrier islands, and coastal marshes (Sherman & Hempel, 2009). The calving grounds for the North Atlantic right whale are located in this large marine ecosystem, as discussed in Section 3.7 (Marine Mammals). The Southeast U.S. Continental Shelf Large Marine Ecosystem supplies important ecosystem services by providing resources for commercial fisheries (e.g., mackerel, swordfish, tuna, white shrimp, brown shrimp) and by supporting these fisheries with estuarine nurseries for these species. The Southeast U.S. Continental Shelf Large Marine Ecosystem includes important breeding areas for sea turtles. This large marine ecosystem is a moderately productive ecosystem, with an average primary productivity of 150–300 g of carbon per m^2 per year (Aquarone, 2009). This is comparable to productivity levels associated with the open ocean.

A large proportion of Navy training and testing activities occur in the Southeast U.S. Continental Shelf Large Marine Ecosystem. To determine which designated training and testing areas (or portions of these areas) occur within this large marine ecosystem, refer to Figure 3.0-1, and for more information on the types of activities that will occur in range complexes within an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 2 percent of the Study Area is located in the Southeast U.S. Continental Shelf Large Marine Ecosystem.

3.0.2.1.6 Gulf of Mexico Large Marine Ecosystem

The Gulf of Mexico Large Marine Ecosystem (Figure 3.0-1) encompasses an area of more than 1,500,000 km^2 (Heileman & Rabalais, 2008). This large marine ecosystem is a semi-enclosed sea that borders the United States, Mexico, and Cuba. This area includes the Florida Keys and Flower Garden Banks National Marine Sanctuaries. For additional details on marine protected areas and national marine sanctuaries, see Section 6.1.2 (Marine Protected Areas).

Oceanic influences in this large marine ecosystem are the Loop Current, Campeche Bank Coastal Front, Campeche Bank Shelf-Slope Front, Inner Shelf Front, Louisiana-Texas Shelf Front, and West Florida Shelf Front. Important structural features of this ecosystem include the extensive continental shelf, numerous estuaries, and a large amount of freshwater input from the Mississippi River (Sherman & Hempel, 2009). The Gulf of Mexico Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., Gulf menhaden, king mackerel, red grouper, brown shrimp, white shrimp, and pink shrimp). This large marine ecosystem has a moderately high average primary productivity of less than 300 g of carbon per m^2 per year (Heileman & Rabalais, 2008). Other human uses in this large marine ecosystem include offshore oil and gas exploration.

A large number of Navy training and testing activities occur in the Gulf of Mexico Large Marine Ecosystem. To determine which designated training and testing areas (or portions of these areas) occur within this large marine ecosystem, refer to Figure 3.0-1, and for more information on the types of activities that will occur in range complexes within an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 13 percent of the Study Area is located in the Gulf of Mexico Large Marine Ecosystem.

3.0.2.1.7 Caribbean Sea Large Marine Ecosystem

The Caribbean Sea Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 3,300,000 km^2. This large marine ecosystem is bordered by the southern part of Florida, Central and South America, and the Antilles (Heileman & Mahon, 2008). Oceanic influences in this area are the Loop Current, North Equatorial Current, and Windward Passage Front. Important structural features of this ecosystem include coral reefs, sea mounts, and major input of freshwater from large rivers (Sherman &

Hempel, 2009). The Caribbean Sea Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., king mackerel, Spanish mackerel, dolphinfish, spiny lobster, queen conch, and shrimp). The Caribbean Sea Large Marine Ecosystem includes important breeding areas for sea turtles, as discussed in Section 3.8 (Reptiles). This region has a moderate primary productivity of 150–300 g of carbon per m^2 per year (Heileman & Mahon, 2008).

To determine which designated training and testing areas (or portions of these areas) occur within the portion of the Caribbean Sea Large Marine Ecosystem that falls within the Study Area, refer to Figure 3.0-1, and for more information on the types of activities that will occur in range complexes within an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 1 percent of the Study Area is located in the Caribbean Sea Large Marine Ecosystem.

3.0.2.1.8 Labrador Current Open Ocean Area

The Labrador Current Open Ocean Area (Figure 3.0-1) lies between Labrador (Canada) and Greenland and is characterized by the cold water of the Labrador Current that flows north to south from the Arctic Ocean, down along the eastern coast of Canada (Reverdin et al., 2003). The Labrador Current then joins the Gulf Stream Current to form the North Atlantic Current (Gould, 1985; Reverdin et al., 2003). The Labrador Current has an average width of 26–50 nautical miles (NM), with typical velocities of 0.3–0.5 meters (m) per second, and flows to a maximum depth of 150 m (Halkin & Rossby, 1985; Reverdin et al., 2003; Tomczak & Godfrey, 2003).

The Arctic influence, combined with the southward-flowing current, results in an abundance of icebergs in this open ocean area, particularly during the spring and early summer months (Reverdin et al., 2003; Schmitz & McCartney, 1993; Tomczak & Godfrey, 2003). The cold-water Labrador Current influences the species assemblages found within this open ocean area (Valiela, 1995). However, farther south where this cold water current combines with the warm waters of the Gulf Stream (offshore of the Newfoundland-Labrador Shelf, Scotian Shelf, and Northeast U.S. Continental Shelf Large Marine Ecosystems), the species assemblage reflects both warm- and cold-water organisms (Aquarone, 2009; Aquarone & Adams, 2009b; Valiela, 1995). The Labrador Current Open Ocean Area is an important feeding and migration area for the Gulf of Maine Atlantic salmon (Fay et al., 2006).

No specifically designated training or testing areas fall within the Labrador Current Open Ocean Area; however, training or testing may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities within and outside of designated training and testing ranges. Approximately 10 percent of the Study Area is located in the Labrador Current Open Ocean Area.

3.0.2.1.9 Gulf Stream Open Ocean Area

The major western boundary current of the North Atlantic, the Gulf Stream, characterizes the Gulf Stream Open Ocean Area (Figure 3.0-1). The Gulf Stream forms where the Loop Current in the Gulf of Mexico (Reverdin et al., 2003) and the Florida Current (Atkinson et al., 1984) combine in the Atlantic Ocean. The Gulf Stream begins where the Florida Current ceases to follow the continental shelf, flowing northeast along the southeastern United States from Cape Canaveral, Florida, to Cape Hatteras, North Carolina (Atkinson & Targett, 1983). As the Gulf Stream moves away from Cape Hatteras, it flows northeast toward Europe (Garrison, 2004).

The Gulf Stream has a maximum width of 200 kilometers (km), with typical velocities exceeding 1.0 m per second, and flows to a maximum depth of 200 m (Halkin & Rossby, 1985; Reverdin et al., 2003;

Tomczak & Godfrey, 2003). The Gulf Stream flows over the shelf break south of 32 degrees (°) North (N) at water depths less than 800 m (Atkinson et al., 1984; Halkin & Rossby, 1985). North of 32° N, the Gulf Stream is displaced 54 NM offshore, at which point it abruptly turns east near the Charleston Bump (a deep-water outcropping) (Reverdin et al., 2003). From there, the Gulf Stream continues northeast, joining the Labrador Current to form the Slope Jet Current at 41° N–42° N. This branch of the Gulf Stream, along with the Labrador and Slope Jet Current, continues northeast as the North Atlantic Current (Gould, 1985; Reverdin et al., 2003).

The Gulf Stream is an important migratory corridor for many different marine species, including marine mammals, sea turtles, and fishes. The influence of the warm waters of the Gulf Stream also provides passive dispersal of tropical species from southern portions of the Study Area into the northern portions of the Study Area.

A large proportion of Navy training and testing activities occur in this open ocean area. To determine which designated training and testing areas (or portions of these areas) occur within the Gulf Stream Open Ocean Area, refer to Figure 3.0-1, and for more information on the types of activities that will occur in range complexes within an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 11 percent of the Study Area is located in the Gulf Stream Open Ocean Area.

3.0.2.1.10 North Atlantic Gyre Open Ocean Area

North Atlantic Ocean circulation is driven by the anticyclonic (clockwise) motion of the North Atlantic Subtropical Gyre (Figure 3.0-1). The North Atlantic Gyre Open Ocean Area occurs from 10° N to 40° N and is delimited by the westward-flowing Canary Current, North Equatorial Current, the Caribbean Current, Loop Current in the Gulf of Mexico, Florida Current, Gulf Stream (Talwani et al., 1971), and the eastward-flowing North Atlantic Current (Schmitz & McCartney, 1993). The North Atlantic Subtropical Gyre is transected by the eastward-flowing Azores Current (Juliano & Alves, 2007). Only the northwestern portion of the North Atlantic Gyre is located in the Study Area. The North Atlantic Gyre, like all large subtropical gyres in the ocean, has extremely low rates of primary productivity (Valiela, 1995). The observed low productivity is caused by a persistent thermocline (a layer of water that separates warm water from cold deep water) that prevents the vertical mixing of water. This thermocline results in dilute (nutrient-poor) surface waters in the gyre, which limits the growth of phytoplankton throughout the year (Valiela, 1995). The Sargasso Sea is a unique feature contained within this gyre, and despite the nutrient limitations of the area, is characterized by dense mats of floating *Sargassum*, a type of marine vegetation (seaweed) that provides important cover habitat for a variety of marine organisms (see Section 3.3, Vegetation, for more details).

To determine which designated training and testing areas (or portions of these areas) occur within the North Atlantic Gyre Open Ocean Area, refer to Figure 3.0-1 and for more information on the types of activities that will occur in range complexes within an ecosystem, refer to Tables 2.3-1 through 2.3-5. Although approximately 50 percent of the Study Area is located in the North Atlantic Gyre Open Ocean Area, the majority of Navy training and testing activities do not occur here.

3.0.2.2 Bathymetry

The discussion of bathymetry includes a general overview of the Study Area followed by more detailed sections organized by biogeographic classification area. Bathymetry describes the surface features of the seafloor, and it is an important factor in understanding the potential impacts of Navy training and testing activities on the seafloor, the propagation of underwater sound, and species diversity.

The contour of the ocean floor as it descends from the shoreline has an important influence on the distribution of organisms, as well as the structure and function of marine ecosystems (Madden et al., 2009). The continental shelf and slope make up the continental margin of oceans. The typical zonation of oceans is shown in Figure 3.0-2.

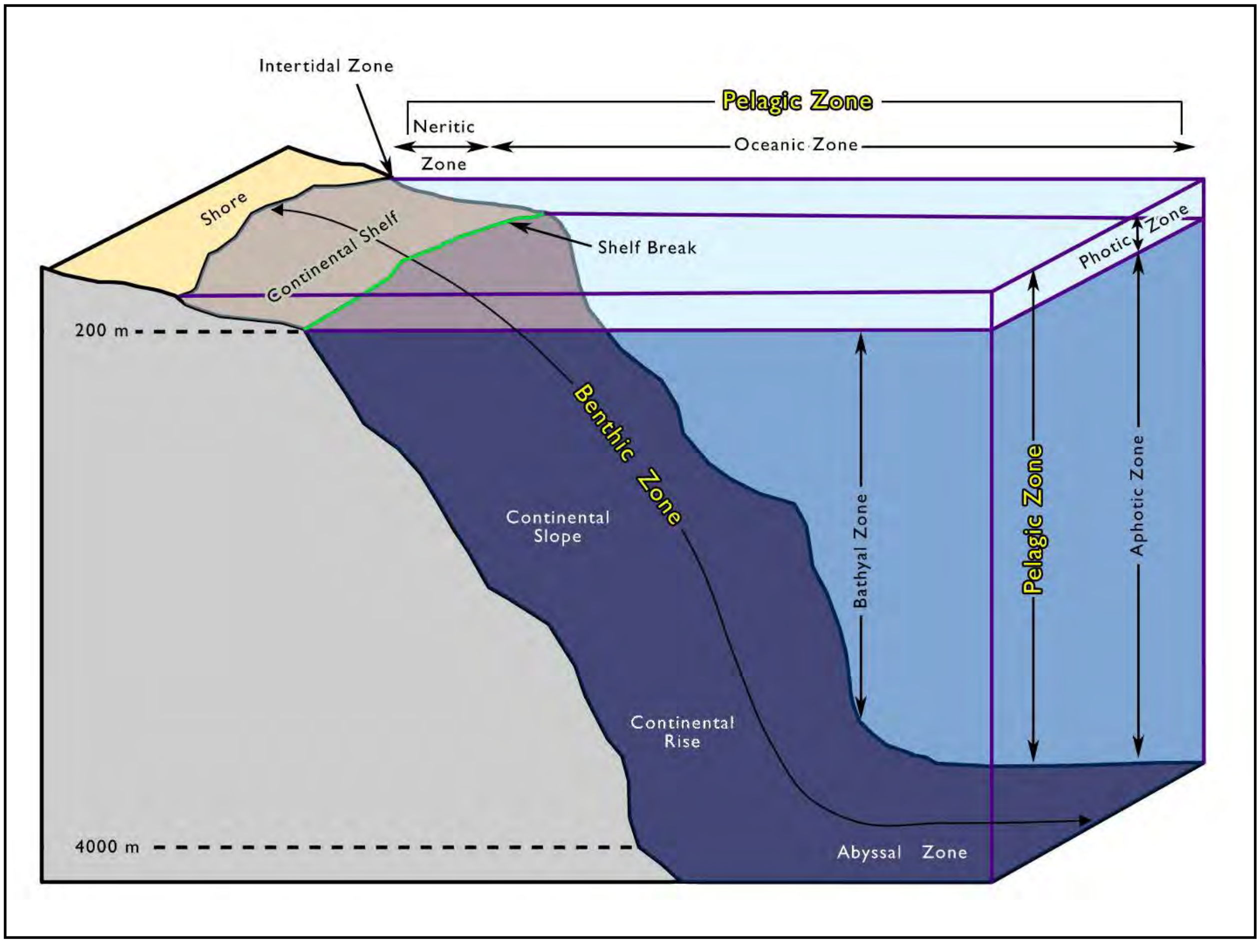
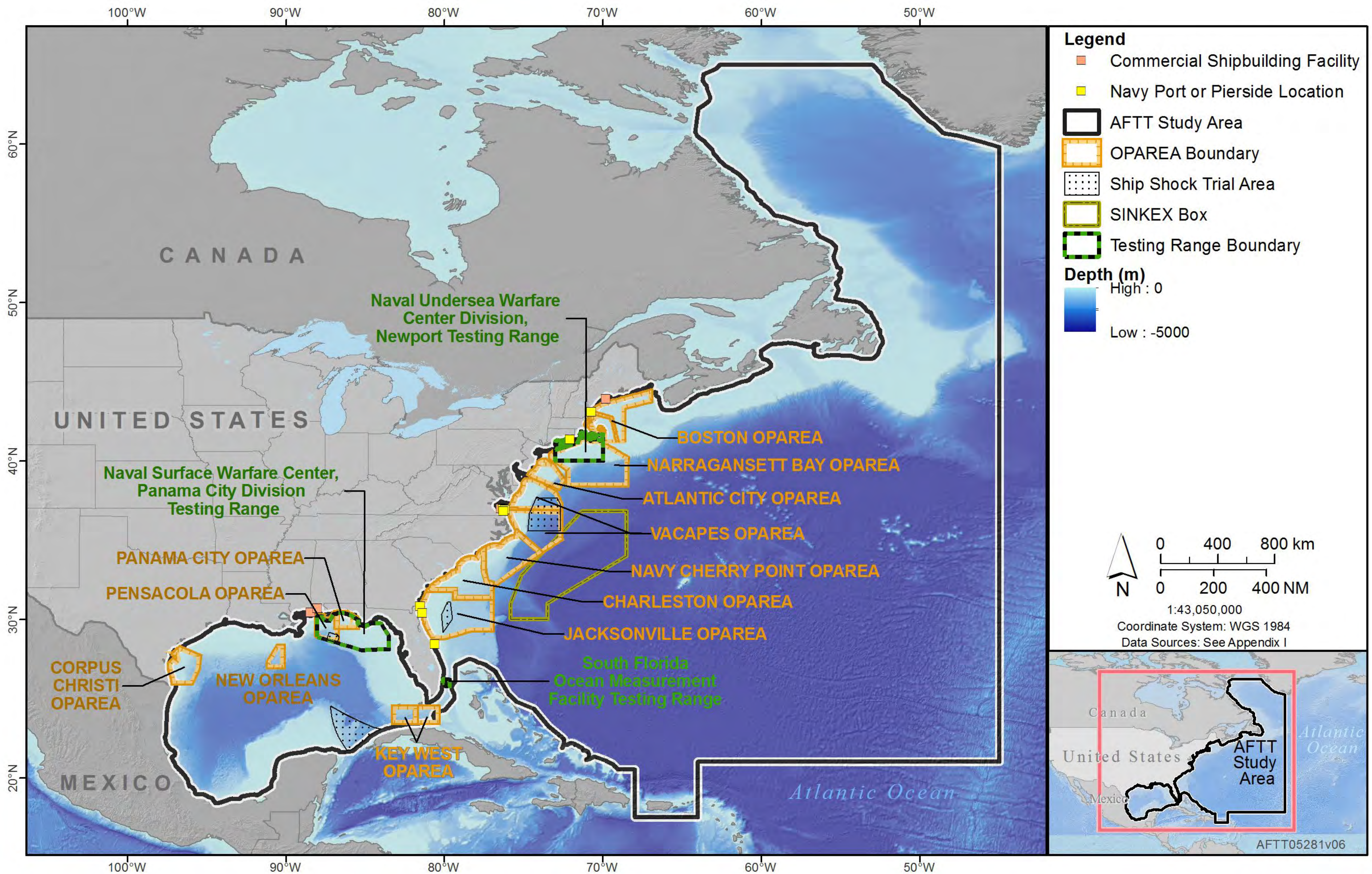


Figure 3.0-2: Three-Dimensional Representation of the Intertidal Zone (shoreline), Continental Margin, Abyssal Zone, and Water Column Zones

The continental shelf gently slopes seaward hundreds of miles (mi.) from shore from the low tide line to a maximum depth of 200 m (Tomczak & Godfrey, 2003; United Nations Educational Scientific and Cultural Organization, 2009). The continental slope is steep; it begins seaward of the shelf break and extends to a depth of approximately 3,000 m. The continental rise extends from the continental slope to a depth of approximately 4,000 m. The abyssal zone, a relatively flat or gently sloping ocean floor, continues from the continental rise to depths of up to approximately 6,500 m. The abyssal zones of the Atlantic Ocean reach depths greater than 6,000 m. Bathymetry of the entire Study Area is shown in Figure 3.0-3 through Figure 3.0-6.

Bathymetric features associated with the continental margin and the deep seafloor of the Study Area include canyons, seamounts (underwater mountains), trenches, ridges, and plateaus. The continental shelf of the northwest Atlantic ranges in width from 5 to 17 NM at its narrowest point off the coast of North Carolina to 215 NM at its widest point off the coast of Newfoundland (Blanton et al., 2003; Slatt, 1984).



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

Figure 3.0-3: Bathymetry of the Entire Study Area

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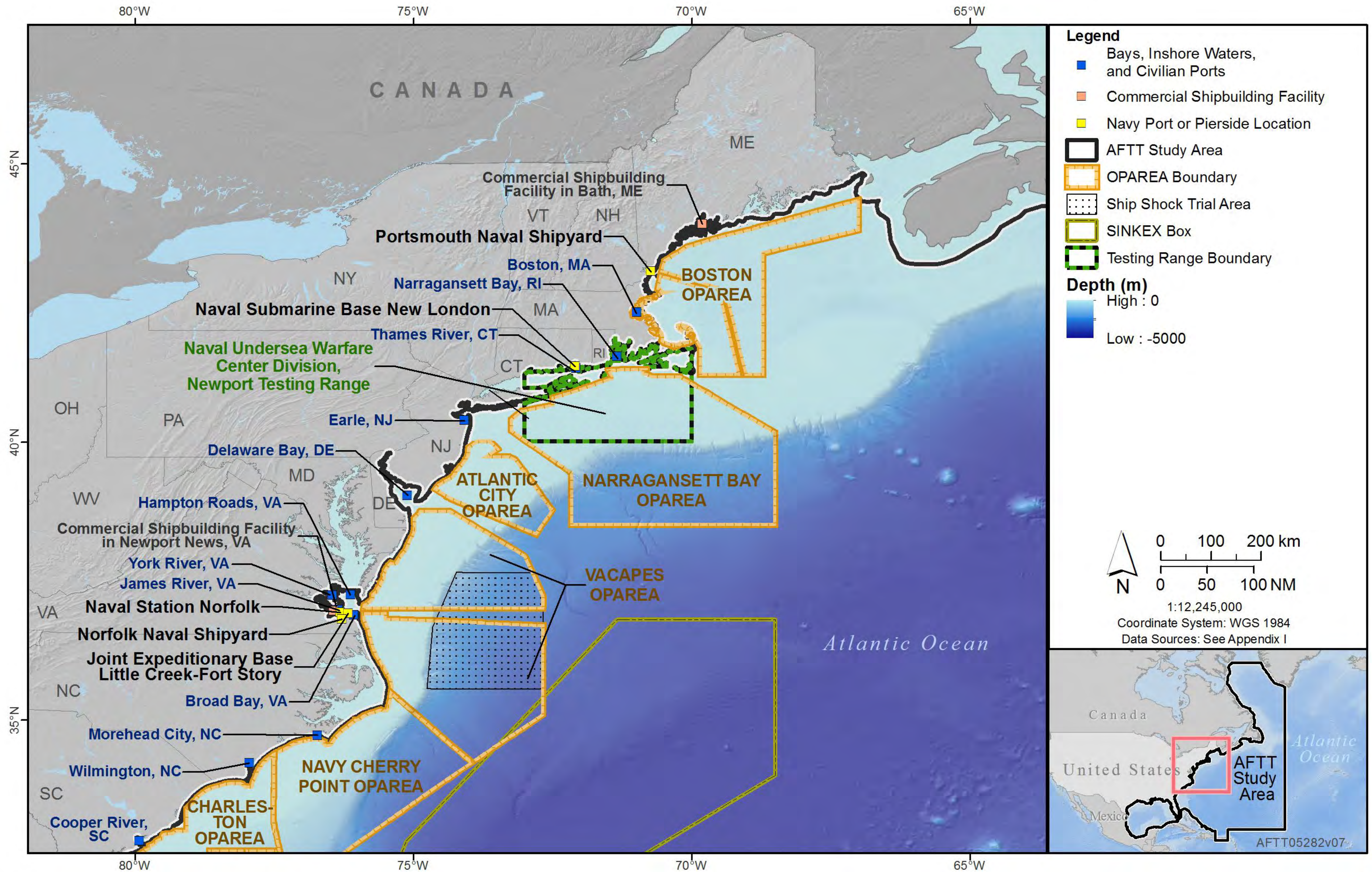

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.0-4: Bathymetry of the Northeast Portion of the Study Area

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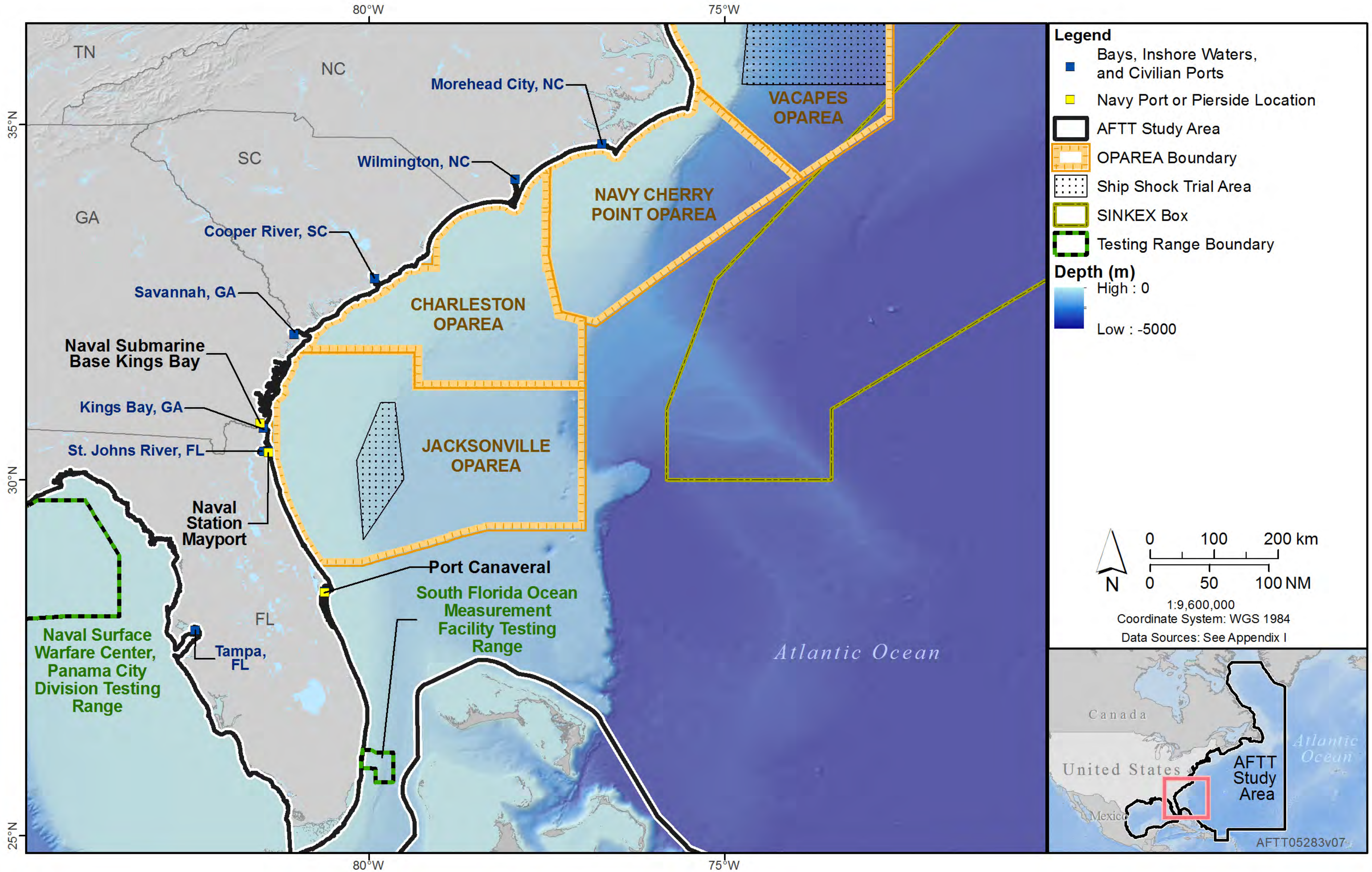

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.0-5: Bathymetry of the Southeast Portion of the Study Area

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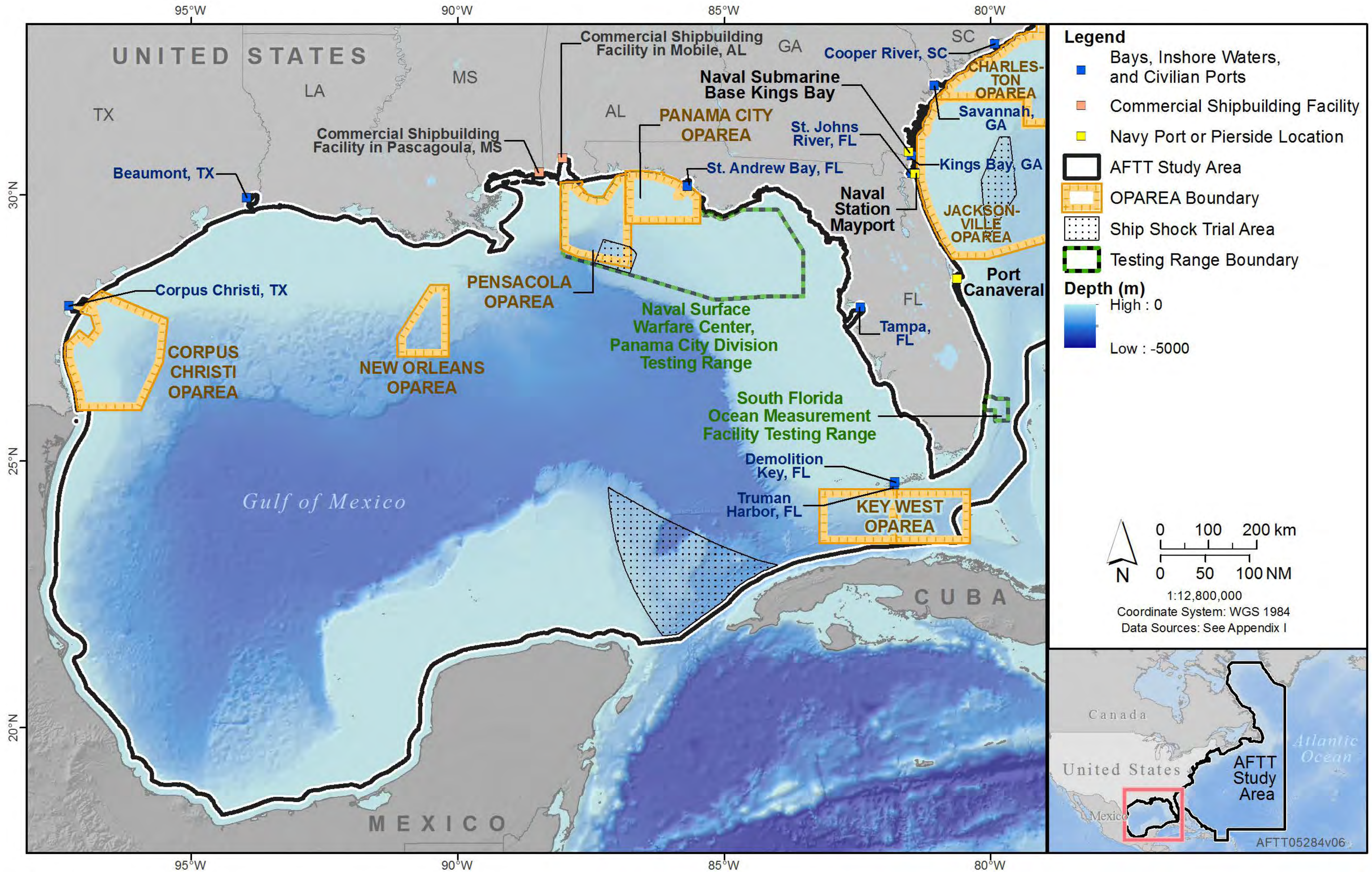

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area

Figure 3.0-6: Bathymetry of the Gulf of Mexico Portion of the Study Area

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Several bathymetric features are located in the Northeast U.S. Continental Shelf, the Scotian Shelf, and the Newfoundland-Labrador Shelf Large Marine Ecosystems. The Grand Banks are a group of shallow underwater plateaus on the eastern extent of the continental shelf in 25–100 m of water. South of the Grand Banks is the Newfoundland Rise, which at 41° N, 50° West (W) is the northernmost extent of the New England Seamount Chain (Reverdin et al., 2003). This chain includes more than 30 volcanic seamounts that extend south to Bermuda.

The Scotian Shelf is bordered by the Canadian province of Nova Scotia and extends offshore to the shelf break, more than 200 NM from the coast (Aquarone & Adams, 2009a). The continental shelf is relatively shallow, with an average depth of 90 m. However, in some areas it rapidly drops to depths greater than 3,000 m. Sable Island, located 160 NM southeast of Halifax, is surrounded by shallow banks (25–100 m).

The Gulf of Maine is a semi-enclosed continental sea with an area of 89,000 km^2 and average depth of 150 m (Ballard & Uchupi, 1974). It is characterized by rocky shorelines of exposed bedrock from previous glacial scouring. Inland of the Gulf of Maine is the Bay of Fundy. It covers 16,500 km^2 with an average depth of 50 m (Wade et al., 1996). The Bay of Fundy and Gulf of Maine are known for having extreme tidal ranges as great as 15 m (Wade et al., 1996).

The Southeast U.S. Continental Shelf Large Marine Ecosystem includes the coastal area from southern Florida to Cape Hatteras, North Carolina (Aquarone, 2009). It includes the topographic feature known as the Blake Plateau, which has water depths of 500–1,100 m (Popenoe & Manheim, 2001). The Blake Plateau is bounded by the continental shelf on the west, Cape Hatteras on the north, the Bahama Banks on the south, and the abyssal plain on the east (Gorsline, 1963; Popenoe & Manheim, 2001). The Charleston Bump, a rocky, high-relief outcrop, occurs on the Blake Plateau between latitude 31° N and 32° N, and between longitude 77.5° W and 79.5° W (Popenoe & Manheim, 2001). The continental shelf in this area has a smooth surface and a low gradient (3° or less), while the continental slope reaches depths of 1,400 m (Knebel, 1984). Portions of the continental slope in this area are associated with deep-water coral communities at depths of 70–1,000 m (Reed & Ross, 2005). At the boundary between the Northeast U.S. Continental Shelf and the Southeast U.S. Continental Shelf, the continental slope is divided by Hatteras Canyon, the most southerly canyon along the continental margin of the U.S. east coast. Offshore of Hatteras Canyon, the continental slope is steep and reaches 5,000 m (Rowe, 1971). Other notable features are large sand shoals that extend from the barrier islands off North Carolina (Hunt et al., 1977; Oertel, 1985).

The average depth of the Gulf of Mexico is 1,615 m, with a maximum depth of 3,850 m (Pequegnat et al., 1990). Dominant features of the Gulf of Mexico include the Sigsbee Escarpment (steep slope) and the Alaminos and Keathley Canyons, which divide the escarpment into western and eastern portions (Minerals Management Service, 2005). The eastern Gulf of Mexico is dominated by the Florida Escarpment, which is divided by a series of submarine canyons and contains more than 90 basins (Minerals Management Service, 2002). The western portion is underlain by the Louann Salt Formation, which creates faults and diapirs (salt domes) often associated with hydrocarbon seeps along the faults. Dominant features in the southern portion of the Gulf of Mexico are the Campeche Escarpment and the Mexican Ridge, which consists of a series of valleys and ridges (Escobar-Briones et al., 2008).

3.0.2.3 Currents, Circulation Patterns, and Water Masses

To analyze the impact of Navy training and testing activities on marine resources (e.g., vegetation and animals) it is important to know where the resources occur in the Study Area. Some of the major factors that influence the distribution of marine resources are currents, circulation patterns, and water masses.

Prevailing winds and the Coriolis effect (the deflection of objects caused by the rotation of the earth) cause surface waters to move in a gyre, or circular fashion, in ocean basins. In the North Atlantic Ocean, this gyre system is composed of the Gulf Stream, North Atlantic, Canary, and Equatorial Currents. In the Gulf of Mexico, the Florida Current is a strong, east-northeast-flowing current that connects the Loop Current to the Gulf Stream at the entrance to the Florida Straits (Figure 3.0-7).

Surface currents are horizontal movements of water primarily driven by the drag of the wind over the sea surface. Wind-driven circulation affects the upper 100 m of the water column and therefore drives the circulation over continental shelves (Hunter et al., 2007). Surface currents of the Atlantic Ocean have an annual average mean velocity of 0.5 m per second and include equatorial currents, circumpolar currents, eastern boundary currents, and western boundary currents (Juliano & Alves, 2007). Refer to Figure 3.0-7 and Table 3.0-1 for a depiction and description of the major surface currents in the Study Area.

Table 3.0-1: Summary of Current Patterns in Areas Located Outside the Range Complexes

Component	*Currents*
Northeast U.S. Continental Shelf Large Marine Ecosystem	
Bath, ME	Riverine and tidal circulation patterns.
Portsmouth Naval Shipyard, Kittery, ME	
Naval Undersea Warfare Center Division, Newport Testing Range	Shallow water coastal currents generated by tidal action and wind. Currents are affected by open-ocean conditions as well as by tidal exchange and wind-generated currents in the estuaries.
Naval Submarine Base New London, Groton, CT	Riverine and tidal circulation patterns near mouth of estuary. Subject to the influence of larger open oceanic currents and circulation systems.
Newport News, VA	
Naval Station Norfolk, Norfolk, VA	
Joint Expeditionary Base Little Creek—Fort Story, Virginia Beach, VA	
Norfolk Naval Shipyard, Portsmouth, VA	
Southeast U.S. Continental Shelf Large Marine Ecosystem	
Naval Submarine Base Kings Bay, Kings Bay, GA	Riverine and tidal circulation patterns in middle part of estuary.
Naval Station Mayport, Jacksonville, FL	Riverine and tidal circulation patterns in the mouth of estuary inlet. Subject to the influence of larger open oceanic currents and circulation systems.
Port Canaveral, FL; South Florida Ocean Measurement Facility, FL	Tidal mixing within shallow dredged channel, plus wind driven circulation.
Gulf of Mexico Large Marine Ecosystem	
Pascagoula, MS; Naval Surface Warfare Center, Panama City Division, FL	Riverine and tidal circulation patterns in mouth of estuary/inlet. Offshore, near coastal areas subject to influence of larger open oceanic current/circulation.

Table 3.0-1: Summary of Current Patterns in Areas Located Outside the Range Complexes (continued)

Component	*Currents*
Gulf of Mexico Large Marine Ecosystem (continued)	
Gulf of Mexico	The Louisiana coast current flows along the coast of the United States from the mouth of the Mississippi River to the western Gulf of Mexico. The Yucatan Current flows north, east, and west as it enters the Gulf of Mexico from the Caribbean Sea. The Loop Current originates as part of the Yucatan Current, and spins in a clockwise direction and connects with the Florida Current from west to east through the Florida Straits. Warm and cold core eddy rings develop in the western half of the Gulf of Mexico between the Loop Current and the Texas/Mexico coast. Cold-core eddy rings develop off the Florida Current in the eastern Gulf.
Caribbean Sea Large Marine Ecosystem	
Other AFTT Areas (Outside the Range Complexes)	The Antilles Current flows southeast to northwest along the northern edge of the Turks and Caicos Islands and Bahama Islands. The Labrador Current flows south from Labrador Bay.
Labrador Current Open Ocean Area	
Other AFTT Areas (Outside the Range Complexes)	Labrador surface current and West Greenland surface current move water in a counter clockwise direction around the outer edges of the Labrador Sea. West Labrador surface current also moves water farther to the north. Portions of the deep North Atlantic Current return cold, denser water back to the south, away from the Labrador Sea.

Source: Stewart, (2008)
Notes: AFTT = Atlantic Fleet Training and Testing, CT = Connecticut, FL = Florida, GA = Georgia, ME = Maine, MS = Mississippi, VA = Virginia

Eastern boundary currents are relatively shallow, broad, and slow-moving and travel toward the equator along the eastern boundaries of ocean basins. Western boundary currents are narrow, deep, and swift and are a result of the trade winds and the westerlies. In general, eastern boundary currents carry cold waters from higher latitudes to lower latitudes, and western boundary currents carry warm waters from lower latitudes to higher latitudes (Reverdin et al., 2003).

In the northern hemisphere, including the Study Area, the influence of the westerlies and the northeasterly trade winds on North Atlantic currents produce the eastward-flowing Subtropical Counter Current (Tomczak & Godfrey, 2003). Subpolar gyres are also present in the North Atlantic as a result of the polar easterlies and the westerlies. In the North Atlantic, subpolar gyres rotate counterclockwise (Tomczak & Godfrey, 2003).

The western continental margin of any ocean basin is the location of intense boundary currents; the Gulf Stream Current is the western boundary current found in the North Atlantic Ocean (Figure 3.0-7). The Gulf Stream Current is part of a larger current system called the Gulf Stream System that also includes the Loop Current in the Gulf of Mexico, the Florida Current in the Florida Straits, and the North Atlantic Current in the central North Atlantic Ocean. The Gulf Stream Current is a powerful surface current, carrying warm water into the cooler North Atlantic just south of the Northeast Range Complexes (Pickard & Emery, 1990; Verity et al., 1993). In general, the Gulf Stream flows roughly parallel to the coastline from the Florida Straits to Cape Hatteras, where it is deflected away from the North American continent and flows northeastward.

The temperature and salinity of water determines its density; density differences cause water masses to move both vertically and horizontally in relation to one another. Cold, salty, dense water at the surface will sink, and warm, less saline water will rise. Density differences also drive the horizontal circulation of deep-water masses throughout ocean basins.

Thermohaline circulation—also called the ocean conveyor belt or meridional overturning—is the continuous horizontal circulation of water masses throughout the ocean. This cycle begins when dense waters sink and deep-water masses form. Deep-water masses form in the North Atlantic and Southern oceans (Dickson & Brown, 1994). North Atlantic Deep Water is formed in the Norwegian Sea between Iceland and Greenland. North Atlantic Deep Water is carried by the Deep Western Boundary Current along the western continental slope to join Antarctic Bottom Water (Dengler et al., 2004; Pickart, 1992). At the surface, waters are heated and freshwater inputs result in lower salinity. As a result of density differences and higher sea levels in the Pacific Ocean and Indian Ocean, these surface water masses return to the Antarctic Ocean and North Atlantic Ocean. In the North Atlantic, these surface waters undergo evaporative cooling, which increases their densities, resulting in the sinking and formation of the North Atlantic Deep Water (Haug & Tiedemann, 1998).

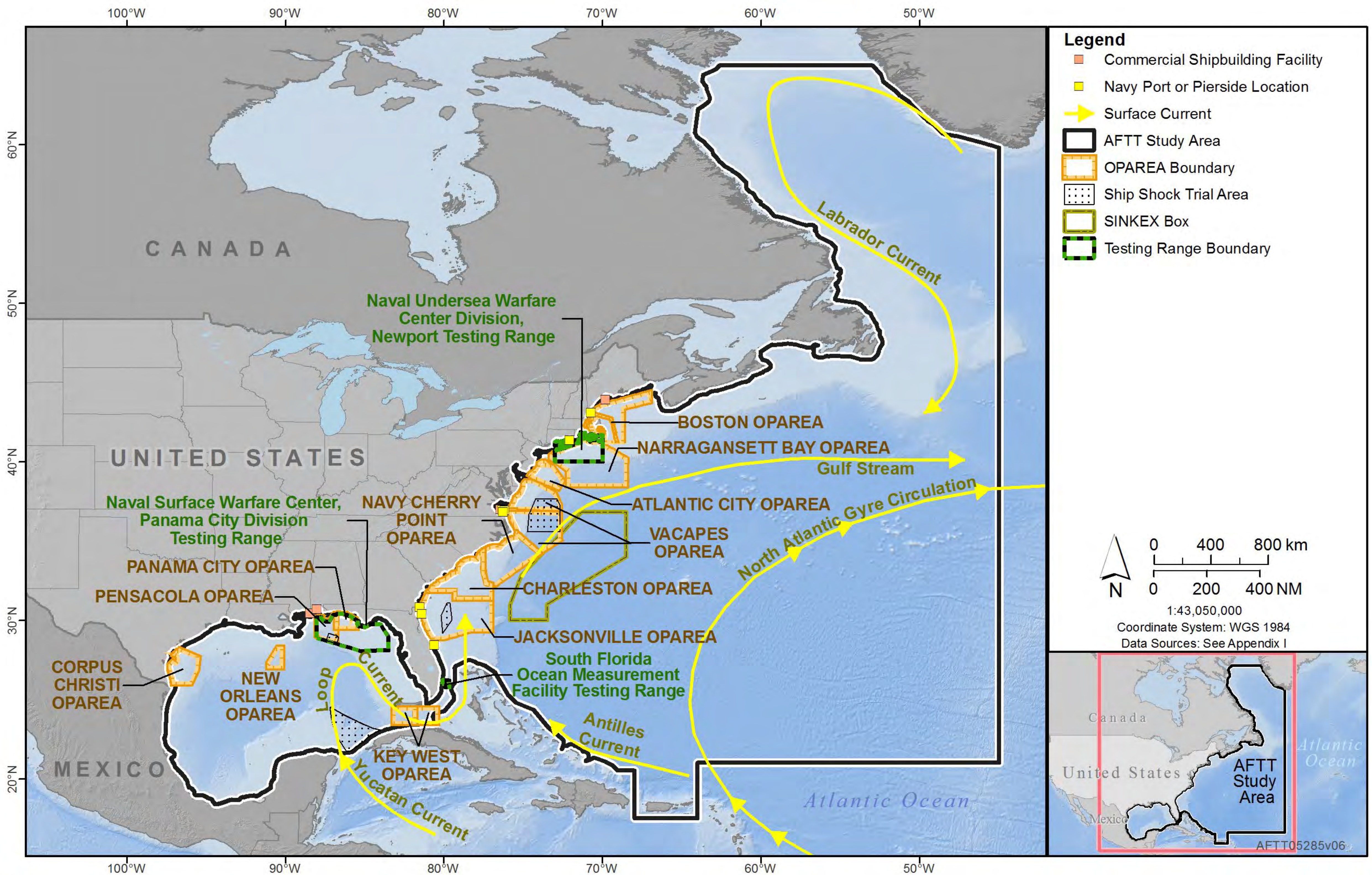
3.0.2.4 Ocean Fronts

Ocean fronts are characterized by increased productivity and biomass (e.g., marine vegetation and animals) (Bost et al., 2009). Fronts are the boundaries between two water masses with distinct temperatures or densities and are characterized by rapid changes in specific water properties over short distances.

The Study Area is influenced by the Mid-Atlantic Bight (a curve in the coastline) shelf break front, the Gulf Stream front, and the Loop Current and Florida Current. As the Gulf Stream Current moves east from Cape Hatteras, North Carolina, it carries warm equatorial waters into the cooler Atlantic Ocean. Cold water flowing north to south from coastal areas of the northeastern United States (as shown in Figure 3.0-7) converges with the warmer waters of the Gulf Stream off Cape Hatteras, creating a frontal system. These fronts can be depicted on maps that show the drastic changes in sea surface temperatures between water masses. Figure 3.0-8 shows the influence of ocean fronts on the sea surface temperatures of the Study Area.

The front formed at the intersection of the continental shelf and slope extends from the Mid-Atlantic Bight into New England waters. This front is biologically important and persists year-round. Phytoplankton (microscopic drifting plants) production is enhanced at this frontal boundary, often with twice the concentration of phytoplankton found in adjacent waters (Ryan et al., 1999).

North of Cape Hatteras, the Gulf Stream meanders in a wave-like fashion and becomes unstable. These instabilities in current flow lead to the pinching off of relatively warm or cool waters as either warm- or cold-core mesoscale eddies (Mann & Lazier, 1996). Mesoscale eddies are large (54–108 NM wide) rotating water currents that separate from the main current. They cause cold, deep waters to rise to the surface (upwelling) or conversely, warm, surface waters to sink (downwelling), and consequently influence primary production (Sangrà et al., 2009) and facilitate the transfer of energy to higher trophic levels (Thompson et al., 2012). Warm-core eddies rotate clockwise (anticyclonic) and bring warm water and associated plankton (drifting organisms), including ichthyoplankton (fish eggs and larvae), to the colder areas of the northeast shelf. Cold-core eddies rotate counterclockwise (cyclonic) and deliver cold, nutrient-rich waters and plankton to the surface of the ocean. These types of mesoscale eddies form around the Gulf Stream and influence the sea surface temperature.



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

Figure 3.0-7: Major Currents in the Study Area

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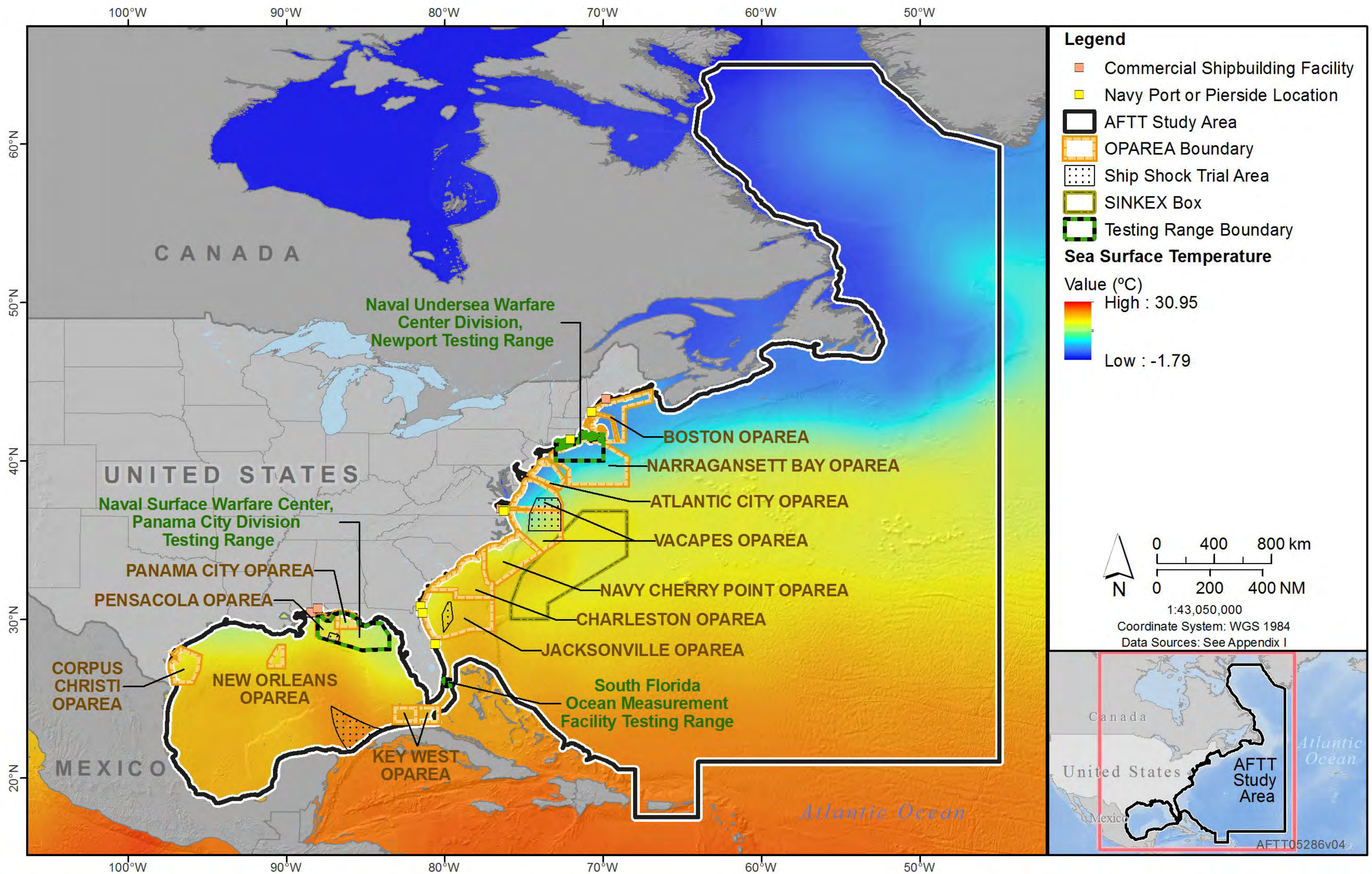

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.0-8: Average Sea Surface Temperature in the Study Area (2011–2015)

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Warm- and cold-core eddy rings develop in the western half of the Gulf of Mexico between the Loop Current and the Texas and Mexico coast. These eddies travel westward and southward in the Gulf (Elliot, 1982; Hamilton, 1990; Minerals Management Service, 2001). The Loop Current and associated eddies are responsible for circulation in the deepest portions of the Gulf of Mexico (Hamilton, 1990). Frontal eddies occur along the East Florida Shelf (Fiechter & Mooers, 2003; Lee et al., 1992) when warm Florida Current front waters meander seaward beyond the shelf break, allowing colder slope waters to upwell onto the East Florida Shelf.

3.0.2.5 Abiotic Substrate

In the marine and estuarine environments of the AFTT Study Area there are a variety of types of surfaces, or substrates, on which organisms live. Nonliving (abiotic) substrates can be categorized based on the grain size of unconsolidated material: "Soft" (e.g., sand, mud), "Intermediate" (e.g., cobble, gravel), and "Hard" (e.g., bedrock, boulders, artificial structures).

3.0.3 Overall Approach to Analysis

The Navy's overall approach to analysis in this EIS/OEIS is consistent with the approach used in previous analyses and included the following general steps:

- identifying resources and stressors for analysis,
- analyzing resource-specific impacts for individual stressors,
- analyzing resource-specific impacts for multiple stressors,
- examining potential marine species population-level impacts,
- analyzing cumulative effects, and
- analyzing mitigations to reduce identified potential impacts.

> Stressor: an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources.

Navy training and testing activities in the Proposed Action may produce one or more stimuli that cause stress on a resource. Each proposed Navy activity was examined to determine its potential stressors. The term stressor is broadly used in this document to refer to an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources. Not all stressors affect every resource, nor do all proposed Navy activities produce all stressors. Since the activities proposed in this EIS/OEIS are similar to current activities analyzed previously, the stressors considered are also similar.

The potential direct, indirect, and cumulative impacts of the Proposed Action were analyzed based on these potential stressors being present with the resource. Data sets used for analysis were considered across the full spectrum of Navy training and testing for the foreseeable future. For the purposes of analysis and presentation within this EIS/OEIS, data was organized and evaluated in one-year and five-year increments. Direct impacts are caused by the action and occur at the same time and place. Indirect impacts result when a direct impact on one resource induces an impact on another resource (referred to as a secondary stressor). Indirect impacts would be reasonably foreseeable because of a functional relationship between the directly impacted resource and the secondarily impacted resource. For example, a significant change in water quality could secondarily impact those resources that rely on water quality, such as marine animals and public health and safety. Cumulative effects or impacts are the incremental impacts of the action added to other past, present, and reasonably foreseeable future actions.

First, a preliminary analysis was conducted to determine the environmental resources potentially impacted and associated stressors. Secondly, each resource was analyzed for potential impacts of individual stressors, followed by an analysis of the combined impacts of all stressors related to the Proposed Action. A cumulative impact analysis was conducted to evaluate the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions (Chapter 4, Cumulative Impacts). Mitigation measures are discussed in detail in Chapter 5 (Mitigation), and regulatory considerations are discussed in Chapter 6 (Regulatory Considerations).

In this sequential approach, the initial analyses were used to develop each subsequent step so the analysis focused on relevant issues (defined during scoping) that warranted the most attention. The systematic nature of this approach allowed the Proposed Action with the associated stressors and potential impacts to be effectively tracked throughout the process. This approach provides a comprehensive analysis of applicable stressors and potential impacts. Each step is described in more detail below.

3.0.3.1 Resources and Issues Evaluated

Physical resources evaluated include air quality, sediments and water quality. Biological resources (including threatened and endangered species) evaluated include vegetation, invertebrates, habitats, fishes, marine mammals, reptiles, and birds and bats. Human resources evaluated include cultural resources, socioeconomic resources, and public health and safety.

3.0.3.2 Resources and Issues Eliminated from Further Consideration

This AFTT EIS/OEIS analyzes only in-water activities and activities occurring over water. Therefore, some resource areas are not analyzed. Resources and issues considered but not carried forward for further consideration include land use, demographics, environmental justice, and children's health and safety. Land use was eliminated from further consideration because the offshore activities in the Proposed Action are not connected to land use issues and no new actions are being proposed that would include relevant land use. Demographics were eliminated from further consideration because the Proposed Action's effects occur at sea away from human populations, and would not result in a change in the demographics within the Study Area or within the counties of the coastal states that abut the Study Area. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, was eliminated as an issue for further consideration because all of the proposed activities occur in the ocean and in harbors and bays, where there are no human residences present. Therefore, there are no disproportionately high and adverse human health or environmental impacts from the Proposed Action on minority populations or low-income populations. Similarly, Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, was eliminated as an issue for further consideration because all of the proposed activities occur in the ocean, where there are no child populations present. Therefore, the Proposed Action would not lead to disproportionate risks to children that result from environmental health risks or safety risks.

3.0.3.3 Identifying Stressors for Analysis

The proposed training and testing activities were evaluated to identify specific components that could act as stressors by having direct or indirect impacts on the environment. This analysis includes identifying the spatial variation of the identified stressors. Matrices were prepared to identify associations between stressors, resources, and the spatial relationships of those stressors, resources, and activities within the Study Area under the Proposed Action. Each stressor includes a description of activities that may generate the stressor. Additional information on these activities and resources is also provided in Appendix B (Activity Stressor Matrices). Stressors for physical resources (air quality, sediments and water quality) and human resources (cultural resources, socioeconomics, and public health and safety) are described in their respective sections of Chapter 3 (Affected Environment and Environmental Consequences).

A preliminary analysis identified the stressor/resource interactions that warrant further analysis in the EIS/OEIS based on public comment received during scoping, previous NEPA analyses, and opinions of subject matter experts. Stressor/resource interactions that were determined to have negligible or no impacts were not carried forward for analysis in the EIS/OEIS. For example, some fixed-wing carrier-based aircraft may jettison fuel prior to an arrested landing to adjust their gross weight to a safe level. However, the fuel is jettisoned at altitudes and airspeeds that evaporate and atomize it before it reaches the water's surface (National Oceanic and Atmospheric Administration, 2016), resulting in no detectable impact to air or water quality.

In subsequent sections, tables are provided in which the annual number of activities that could involve a particular stressor are totaled by alternative and by location, within the categories of training and testing. For example, see Table 3.0-14. It is important to note that the various tables are not exclusive of each other, and that the stressors from a single named activity from Chapter 2 (Description of Proposed Action and Alternatives) could show up on several tables. For example, the activity Anti-Submarine Warfare Tracking Exercise – Helicopter could include acoustic stressors that would appear on Table 3.0-2, physical disturbance stressors (Table 3.0-32), strike stressors (Table 3.0-36), entanglement stressors (Table 3.0-39), and ingestion stressors (Table 3.0-32). Also, activities are not always conducted independently of each other. For example, there are instances where a training activity could occur on a vessel while another training activity or a testing activity is being conducted on the same vessel simultaneously. Finally, note that some of the tables that follow in this section count individual items expended (see Table 3.0-24) while others count the annual number of activities in which that stressor could occur at least once during the conduct of that activity (see Table 3.0-14).

3.0.3.3.1 Acoustic Stressors

This section describes the characteristics of sounds produced during naval training and testing and the relative magnitude and location of these sound-producing activities. This provides the basis for analysis of acoustic impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). Explanations of the terminology and metrics used when describing sound in this EIS/OEIS are in Appendix D (Acoustic and Explosive Concepts).

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 hazardous characteristics (see Section 3.0.3.3.2, Explosive Stressors). Characteristics of each of these sound sources are described in the following sections.

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, a series of source classifications, or source bins, were developed. The source classification bins do not include the broadband sounds produced incidental to pile driving; vessel and aircraft transits; and weapons firing.

The use of source classification bins provides the following benefits:

- Provides the ability for new sensors or munitions to be covered under existing authorizations, as long as those sources fall within the parameters of a "bin";
- Improves efficiency of source utilization data collection and reporting requirements anticipated under the MMPA authorizations;
- Ensures a conservative approach to all impact estimates, as all sources within a given class are modeled as the most impactful source (highest source level, longest duty cycle, or largest net explosive weight) within that bin;
- Allows analyses to be conducted in a more efficient manner, without any compromise of analytical results; and
- Provides a framework to support the reallocation of source usage (hours/explosives) between different source bins, as long as the total numbers of takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training and testing requirements, which are linked to real world events.

3.0.3.3.1.1 Sonar and Other Transducers

Active sonar and other transducers emit non-impulsive sound waves into the water to detect objects, safely navigate, and communicate. Passive sonars differ from active sound sources in that they do not emit acoustic signals; rather, they only receive acoustic information about the environment, or listen. In this EIS/OEIS, the terms sonar and other transducers will be used to indicate active sound sources unless otherwise specified.

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 enemy 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 kilohertz [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. The effects of these factors are explained in Appendix D (Acoustic and Explosive Concepts). Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the Study Area.

The sound sources and platforms typically used in naval activities analyzed in the EIS/OEIS are described in Appendix A (Navy Activity Descriptions). Sonars and other transducers used to obtain and transmit information underwater during Navy training and testing activities generally fall into several categories of use described below.

Anti-Submarine Warfare

Sonar used during anti-submarine warfare would impart the greatest amount of acoustic energy of any category of sonar and other transducers analyzed in this EIS/OEIS. Types of sonars used to detect enemy vessels include hull-mounted, towed, line array, sonobuoy, helicopter dipping, and torpedo sonars. In addition, acoustic targets and decoys (countermeasures) may be deployed to emulate the sound signatures of vessels or repeat received signals.

Most anti-submarine warfare sonars are mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets with distance over which threats can be identified. However, some sources may use higher or lower frequencies. Duty cycles can vary widely, from rarely used to continuously active. For example, anti-submarine warfare sonars can be wide-angle in a search mode or highly directional in a track mode.

Most anti-submarine warfare activities involving submarines or submarine targets would occur in waters greater than 600 feet (ft.) deep due to safety concerns about running aground at shallower depths. Sonars used for anti-submarine warfare activities would typically be used beyond 12 NM from shore. Exceptions include use of dipping sonar by helicopters, maintenance of systems while in port, and system checks while transiting to or from port.

Mine Warfare, Small Object Detection, and Imaging

Sonars used to locate mines and other small objects, as well those used in imaging (e.g., for hull inspections or imaging of the seafloor), are typically high frequency or very high frequency. Higher frequencies allow for greater resolution and, due to their greater attenuation, are most effective over shorter distances. Mine detection sonar can be deployed (towed or vessel hull-mounted) at variable depths on moving platforms (ships, helicopters, or unmanned vehicles) to sweep a suspected mined area. Hull-mounted anti-submarine sonars can also be used in an object detection mode known as "Kingfisher" mode. Sonars used for imaging are usually used in close proximity to the area of interest, such as pointing downward near the seafloor.

Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 200 ft. and at established training minefields, temporary minefields close to strategic ports and harbors, or at targets of opportunity such as navigation buoys. Kingfisher mode on vessels is most likely to be used when transiting to and from port. Sound sources used for imaging could be used throughout the Study Area.

Navigation and Safety

Similar to commercial and private vessels, Navy vessels employ navigational acoustic devices including speed logs, Doppler sonars for ship positioning, and fathometers. These may be in use at any time for safe vessel operation. These sources are typically highly directional to obtain specific navigational data.

Communication

Sound sources used to transmit data (such as underwater modems), provide location (pingers), or send a single brief release signal to bottom-mounted devices (acoustic release) may be used throughout the Study Area. These sources typically have low duty cycles and are usually only used when it is desirable to send a detectable acoustic message.

Classification of Sonar and Other Transducers

Sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose of use. Below, 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. Unless stated otherwise, a reference distance of 1 meter is used for sonar and other transducers.

- 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 Study Area are shown in Table 3.0-2. While general parameters or source characteristics are shown in the table, actual source parameters are classified.

Table 3.0-2 shows the bin use that could occur in any year under each action alternative 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 Chapter 2 (Description of Proposed Action and Alternatives). The five-year total for both action alternatives takes that variability into account.

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed

Source Class Category	Bin	Description	Unit[1]	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual[2]	5-year Total	Annual[2]	5-year Total	Annual[2]	5-year Total	1-year	5-year Total
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	LF sources greater than 200 dB	H	0	0	0	0	1,308	6,540	1,308	6,540
	LF4	LF sources equal to 180 dB and up to 200 dB	H	0	0	0	0	971	4,855	971	4,855
			C	0	0	0	0	20	100	20	100
	LF5	LF sources less than 180 dB	H	9	43	9	43	1,752	8,760	1,752	8,760
	LF6	LF sources greater than 200 dB with long pulse lengths	H	145–175	784	204	1,020	40	200	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	7,081	35,404	3,337	16,684	3,337	16,684
	MF1K	Kingfisher mode associated with MF1 sonars	H	117	585	117	585	152	760	152	760
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	2,078–2,097	10,428	2,116	10,580	1,257	6,271	1,257	6,271
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)	H	591–611	2,994	630	3,150	370–803	2,624	761-803	3,847
	MF5	Active acoustic sonobuoys (e.g., DICASS)	C	6,708–6,836	33,796	6,964	34,820	5,070–6,182	27,412	6,382	31,908

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed (continued)

Source Class Category	Bin	Description	Unit	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz (continued)	MF6	Active underwater sound signal devices (e.g., MK 84)	C	0	0	0	0	1,256–1,341	6,390	1,391	6,955
	MF8	Active sources (greater than 200 dB) not otherwise binned	H	0	0	0	0	348	1,740	348	1,740
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	0	0	7,395–7,562	37,173	7,561	37,172
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	870	4,348	870	4,348	5,690	28,450	5,690	28,450
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	873–1,001	4,621	1,399	6,995	1,424	7,120	1,424	7,120
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	367–397	1,894	596	2,980	1,388	6,940	1,388	6,940
	MF14	Oceanographic MF sonar	H	0	0	0	0	1,440	7,200	1,440	7,200

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed (continued)

Source Class Category	*Bin*	*Description*	*Unit*	*Training*				*Testing*			
				Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
				Annual	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*
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	1,935	9,672	397	1,979	397	1,979
	HF3	Other hull-mounted submarine sonars (classified)	H	0	0	0	0	31	154	31	154
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	H	5,411–6,371	29,935	6,371	31,855	30,772–30,828	117,916	30,828	118,140
	HF5	Active sources (greater than 200 dB) not otherwise binned	H	0	0	0	0	1,864–2,056	9,704	2,056	10,280
			C	0	0	0	0	40	200	40	200
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	0	0	2,193	10,868	2,193	10,868
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	0	0	0	0	1,224	6,120	1,224	6,120
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)	H	20	100	20	100	2,084	10,419	2,084	10,419

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed (continued)

Source Class Category	*Bin*	*Description*	*Unit*	*Training*				*Testing*			
				Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
				Annual	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*
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	H	0	0	0	0	12	60	12	60
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	1,040	5,200	820	4,100	820	4,100
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	C	1,476–1,556	7,540	1,636	8,180	4,756–5,606	25,480	6,106	30,530
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	4,485–5,445	24,345	6,690	34,800	2,941–3,325	15,472	3,325	16,623
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)	C	425–431	2,137	437	2,185	3,493	17,057	3,493	17,057
	ASW5[3]	MF sonobuoys with high duty cycles	H	572–652	3,020	732	3,660	608–628	3,080	708	3,540

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed (continued)

Source Class Category	Bin	Description	Unit	Training Alternative 1 Annual	Training Alternative 1 5-year Total	Training Alternative 2 Annual	Training Alternative 2 5-year Total	Testing Alternative 1 Annual	Testing Alternative 1 5-year Total	Testing Alternative 2 Annual	Testing Alternative 2 5-year Total
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	57	285	806–980	4,336	980	4,840
	TORP2	Heavyweight torpedo (e.g., MK-48)	C	80	400	80	400	344–408	1,848	408	2,040
	TORP3	Heavyweight torpedo (e.g., MK-48)	C	0	0	0	0	100	440	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	0	0	1,224	6,120	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	0	0	634	3,169	634	3,169

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed (continued)

Source Class Category	Bin	Description	Unit	Training: Alternative 1: Annual	Training: Alternative 1: 5-year Total	Training: Alternative 2: Annual	Training: Alternative 2: 5-year Total	Testing: Alternative 1: Annual	Testing: Alternative 1: 5-year Total	Testing: Alternative 2: Annual	Testing: Alternative 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	0	0	176	880	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	0	0	960	4,800	960	4,800
	SAS2	HF SAS systems	H	0–8,400	25,200	8,400	25,200	3,512	17,560	3,512	17,560
	SAS3	VHF SAS systems	H	0	0	0	0	960	4,800	960	4,800
	SAS4	MF to HF broadband mine countermeasure sonar	H	0	0	0	0	960	4,800	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	0	0	960	4,800	960	4,800
	BB2	HF to VHF mine countermeasure sonar	H	0	0	0	0	960	4,800	960	4,800
	BB4	LF to MF oceanographic source	H	0	0	0	0	876–3,252	6,756	3,252	6,756

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed (continued)

				Training				*Testing*			
				Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
Source Class Category	*Bin*	*Description*	*Unit*	*Annual*	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*
Broadband Sound Sources (BB) (continued): Sonar systems with large frequency spectra, used for various purposes	BB5	LF to MF oceanographic source	H	0	0	0	0	672	3,360	672	3,360
	BB6	HF oceanographic source	H	0	0	0	0	672	3,360	672	3,360
	BB7	LF oceanographic source	C	0	0	0	0	120	600	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 Chapter 2, Description of Proposed Action and Alternatives.
[3]Formerly ASW2 (H) in Phase II.

There are 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, which are not anticipated to result in takes of protected species. These sources are categorized as *de minimis* sources and are qualitatively analyzed to determine the appropriate determinations under NEPA in the appropriate resource impact analyses, as well as under the MMPA and the ESA. 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 Study 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 3.0-3: 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 exclude the possibility of any significant impact to a protected species (actual source parameters are classified). Even if there is a possibility that some species may be exposed to and detect some of these sources, any response is expected to be short-term and inconsequential.

Table 3.0-3: Sonar and Transducers Qualitatively Analyzed

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 30º) • 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)

Table 3.0-3: Sonar and Transducers Qualitatively Analyzed (continued)

Source Class Category	*Bin*	*Characteristics*
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)

3.0.3.3.1.2 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 cubic inches would be used during testing activities in various offshore areas in the AFTT Study Area, as well as near shore at Newport, Rhode Island. Table 3.0-4 shows the number of air gun shots proposed in the AFTT Study Area.

Table 3.0-4: Training and Testing Air Gun Sources Quantitatively Analyzed in the Study Area

			Training				*Testing*			
			Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
Source Class Category	*Bin*	*Unit*[1]	*Annual*	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*	*Annual*	*5-year Total*
Air Guns (AG): Small underwater air guns	AG	C	0	0	0	0	604	3,020	604	3,020

[1] C = count. One count (C) of AG is equivalent to 100 air gun firings.

Generated impulses would have short durations, typically a few hundred milliseconds, with dominant frequencies below 1 kHz. The root-mean-square sound pressure level (SPL) and peak pressure (SPL peak) at a distance 1 m from the air gun would be approximately 215 dB re 1 µPa and 227 dB 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 lower SPLs and sound exposure level (SEL) per shot.

For the specific applications and use of air guns in the AFTT Study Area, air guns were analyzed based on 1, 10, and 100 firings. Ten firings of an air gun was a conservative estimate of the number of firings that could occur over a single exposure duration at a single location. One hundred firings was based on pierside use of air guns.

3.0.3.3.1.3 Pile Driving

Impact pile driving and vibratory pile removal would occur during training for the construction of an Elevated Causeway System, a temporary pier that allows the offloading of ships in areas without a permanent port.

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 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 & Dahl, 2011) (note this shock wave has very low peak pressure compared to a shock wave from an explosive). An impact pile driver generally operates on average 35 blows 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.

The source levels of the noise produced by impact pile driving and vibratory pile removal from an actual elevated causeway pile driving and removal are shown in Table 3.0-5.

Table 3.0-5: Elevated Causeway System Pile Driving and Removal Underwater Sound Levels

Pile Size &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 peak 182 dB re 1 $μPa^2s$ SEL (single strike)
24-in. Steel Pipe Pile	Vibratory[2]	146 dB re 1 μPa SPL rms 145 dB re 1 $μPa^2s$ SEL (per second of duration)

[1] (Illingworth and Rodkin, 2017), [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

In addition to underwater noise, the installation and removal of piles also results in airborne noise in the environment. Impact pile driving creates in-air impulsive sound about 100 dBA re 20 μPa at a range of 15 m (Illingworth and Rodkin, 2017). During vibratory extraction, the three aspects that generate airborne noise are the crane, the power plant, and the vibratory extractor. The average sound level recorded in air during vibratory extraction was about 85 dBA re 20 µPa (94 dB re 20 µPa) within a range of 10 to 15 m (Illingworth and Rodkin, 2015).

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. During training exercises, Elevated Causeway System construction is continued until personnel become proficient in the operation of the pile driving equipment and construction techniques. The size of the pier and number of piles used in an Elevated Causeway System training event is assumed to be no greater than 1,520 ft. long, requiring 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 approximately 10 days. Crews would remove about 12 piles per 24-hour period, each taking about six minutes to remove. Table 3.0-6 summarizes the pile driving and pile removal activities that would occur during a 24-hour period.

Table 3.0-6: Summary of Pile Driving and Removal Activities per 24-Hour Period

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

Pile driving for the Elevated Causeway System 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 hertz (Hz) (Hildebrand, 2009). 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.

3.0.3.3.1.4 Vessel Noise

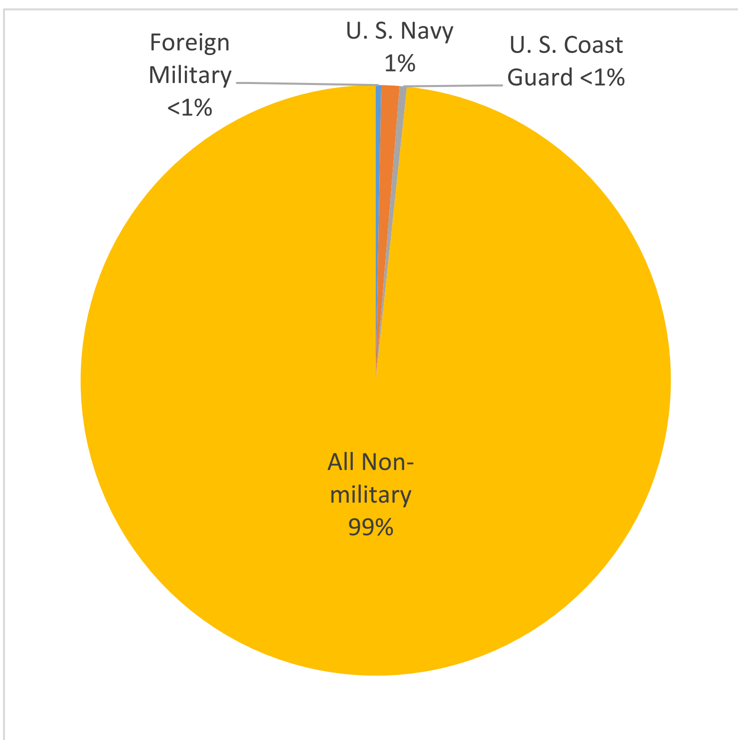
Vessel noise, in particular commercial shipping, is a major contributor to noise in the ocean and inshore waters. Frisk (2012) reported that between 1950 and 2007 ocean noise in the 25–50 Hz frequency range has increased 3.3 dB per decade, resulting in a cumulative increase of approximately 19 dB over a baseline of 52 dB. The increase in noise is associated with an increase in commercial shipping, which correlates with global economic growth (Frisk, 2012).

Naval vessels (including ships and small craft) would produce low-frequency, broadband underwater sound, though the exact level of noise produced varies by vessel type. However, within the AFTT Study Area, Navy vessels represent a small amount of overall vessel traffic and an even smaller amount of overall vessel traffic noise. As shown in Table 3.0-7 and Figure 3.0-9, Navy ships make up roughly 1 percent of the vessel presence in the AFTT Study Area (Mintz, 2016). In terms of anthropogenic noise, Navy ships are engineered to be as quiet as possible given ship class limitations, and would contribute a correspondingly smaller amount of shipping noise compared to more common commercial shipping and boating (Mintz, 2012; Mintz & Filadelfo, 2011). Exposure to vessel noise would be greatest in the areas of highest vessel traffic. Within the Study Area, commercial traffic is heaviest along the U.S. East Coast and the northern coast of the Gulf of Mexico and follows distinct overseas routes and across the Gulf of Mexico. Navy traffic in the Study Area is concentrated along the U.S. East Coast between the mouth of the Chesapeake Bay and Jacksonville, Florida (Mintz, 2012), although vessels would be used during many training and testing activities proposed throughout the Study Area. Noise exposure due to naval vessels would be greatest near naval port facilities, especially around and between the ports of Norfolk, Virginia, and Jacksonville, Florida (Mintz & Parker, 2006).

Table 3.0-7: Interpolated Ship-Hours from 2011 to 2015 Positional Records in the Study Area

Ship Category	***AFTT***
U.S. Navy	525,000
U.S. Coast Guard	337,000
Foreign Military	107,000
Nonmilitary	70,478,000

Note: Interpolated SeaLink data from 2011 through 2015 which represents an unknown fraction of actual vessel traffic. This data represents a relative traffic level, not absolute ship presence (Mintz, 2016)



Source: Mintz (2016)

Figure 3.0-9: AFTT Surface Ship Traffic By Percent Ship-Hours 2011-2015 (Mintz, 2016)

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 & Filadelfo, 2011). Anti-submarine warfare surface combatants (such as guided missile destroyers and cruisers) and submarines make up a large part of Navy traffic but contribute little noise to the overall sound budget of the oceans as these vessels are designed to be quiet to minimize detection. These vessels are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise (Mintz & Filadelfo, 2011). A variety of smaller craft that vary in size and speed, such as service vessels for routine operations and opposition forces used during training and testing events, would be operating within the Study Area.

Studies to determine traffic patterns of Navy and non-Navy vessels in the Study Area were conducted by the Center for Naval Analysis (Mintz & Parker, 2006; Mintz & Filadelfo, 2011; Mintz, 2012). The most recent analysis covered the period 2011-2015 (Mintz, 2016) and included U.S. Navy surface ship traffic and non-military vessels such as cargo vessels, bulk carriers, commercial fishing vessels, oil tankers, passenger vessels, tugs, and research vessels. Caveats to this analysis include that only vessels over 65 ft. in length are reported so smaller Navy vessels and civilian craft are not included, and vessel position records are much more frequent for Navy vessels than for commercial vessels. Therefore, the Navy is likely overrepresented in the data and the reported fraction of total energy is likely the upper limit of its contribution (Mintz & Filadelfo, 2011; Mintz, 2012).

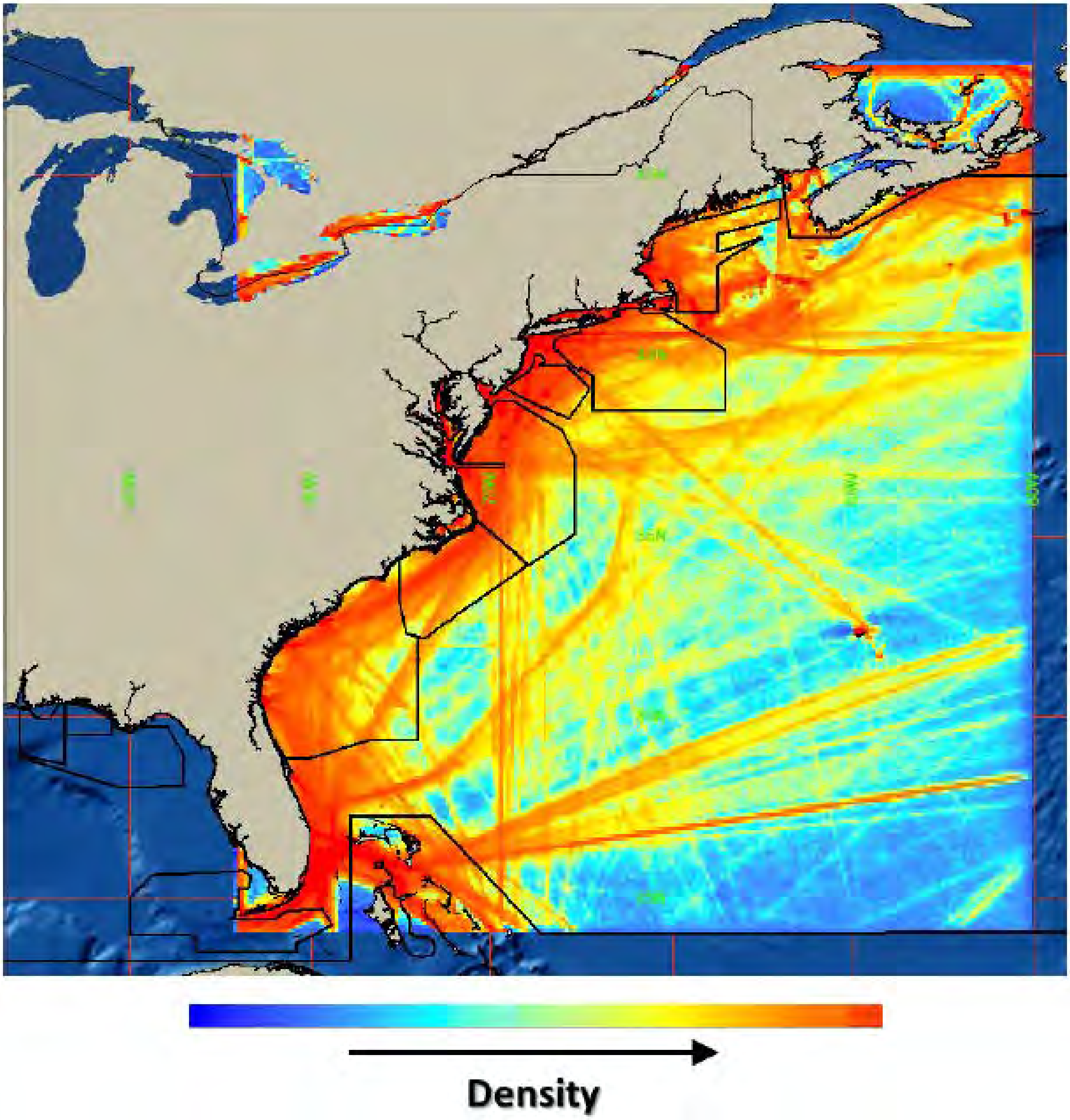
During training and testing, speeds of most large naval vessels (greater than 60 ft.) generally range from 10 to 15 knots to limit fuel consumption; however, ships will, on occasion, operate at higher speeds within their specific operational capabilities. Mintz (2016) reported median speeds for U.S. Navy vessel and various commercial ship classes (Table 3.0-8) in the AFTT Study Area from 2011-2015. Radiated noise from ships varies depending on the nature, size, and speed of the ship. Due to the large number of variables that determine the sound level radiated from vessels, this source will be analyzed qualitatively. 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 & Filadelfo, 2011). 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 & Filadelfo, 2011). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below 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 & Filadelfo, 2011; Richardson et al., 1995; Urick, 1983). 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., 2012). Small craft 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.

Table 3.0-8: Median Surface Ship Speeds for the AFTT Study Area 2011–2015

Ship Class	*Median Ship Speed (knots)*
U.S. Navy Aircraft Carrier	14.6
U.S. Navy Cruiser or Destroyer	11.0-11.4
U.S. Navy Amphibious Assault Ship	11.8-14.1
Commercial Cargo Ship	11.8
Commercial Tanker	10.9
Passenger Ship	10.1

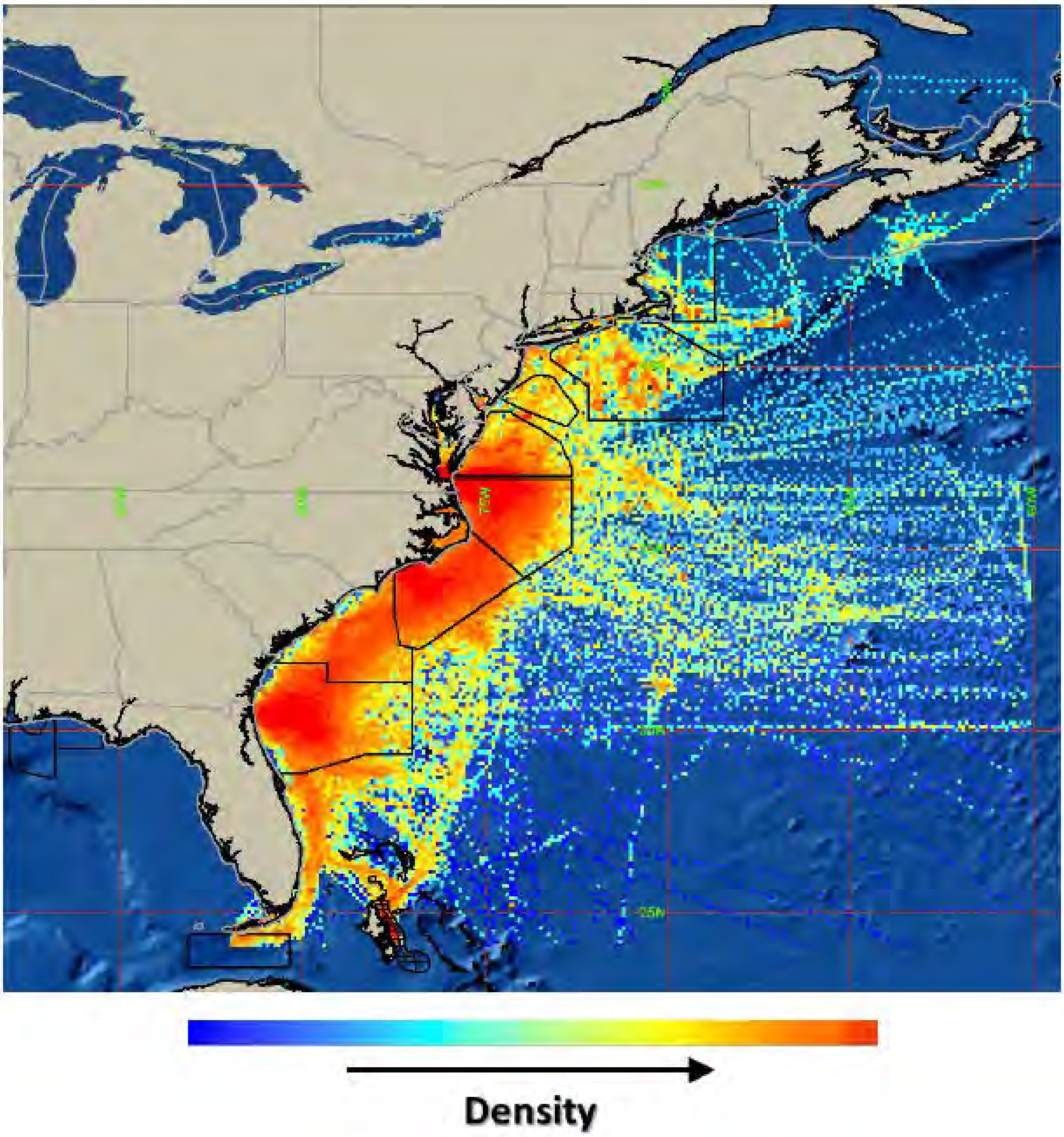
Source: Mintz (2016)

Figure 3.0-10 and Figure 3.0-11 show the geographic distribution of commercial and Navy shipping in the AFTT Study Area derived from the analysis in Mintz (2016). Mintz (2016) shows the geographic distribution of highest Navy surface ship activity within the range complexes south of Hampton Roads, with clear concentrations in and out of Hampton Roads, Virginia and Naval Station Mayport, Florida. Figure 3.0-10 highlights the commercial routes along the East Coast of the U.S. and around the Bahamas. Also seen are great circle routes in the Atlantic Ocean.



Source: Mintz (2016)

Figure 3.0-10: Relative Distribution of Commercial Vessel Traffic



Source: Mintz (2016)

Figure 3.0-11: Relative Distribution of U.S. Navy Vessel Traffic

3.0.3.3.1.5 Aircraft Noise

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area, contributing both airborne and underwater sound to the ocean environment. Sounds in air are often measured using A-weighting, which adjusts received sound levels based on human hearing abilities (see Appendix D, Acoustic and Explosive Concepts). 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 Study Area from established airfields on land. The majority of aircraft noise would be generated at air stations, which are outside the Study Area. Takeoffs and landings occur at established airfields as well as on vessels across the Study 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. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 3.0-9 provides source levels for some typical aircraft used during training and testing in the Study Area and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D during takeoff.

Table 3.0-9: Representative Aircraft Sound Characteristics

Noise Source	*Sound Pressure Level*
In-Water Noise Level	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	152 dB re 1 µPa at 2 m below water surface[1]
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 µPa at 2 m below water surface[1]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	Approximately 125 dB re 1 µPa at 1 m below water surface[2*]
Airborne Noise Level	
F/A-18C/D Under Military Power	143 dBA re 20 µPa at 13 m from source[3]
F/A-18C/D Under Afterburner	146 dBA re 20 µPa at 13 m from source[3]
F35-A Under Military Power	145 dBA re 20 µPa at 13 m from source[3]
F-35-A Under Afterburner	148 dBA re 20 µPa at 13 m from source[3]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	113 dBA re 20 µPa[2]
F-35A Takeoff Through 1,000 ft. (300 m) Altitude	119 dBA re 20 $\mu Pa^2 s$[4**](per second of duration)
EA-18G Takeoff Through 1,622 ft. (500 m) Altitude	115 dBA re 20 $\mu Pa^2 s$ [5**](per second of duration)

[1]Eller and Cavanagh (2000)
[2]Bousman and Kufeld (2005)
[3]U.S. Naval Research Advisory Committee (2009)
[4]U.S. Department of the Air Force (2016)
[5]U.S. Department of the Navy (2012a)
*estimate based on in-air level
**average sound exposure level
Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s), ft. = feet

Underwater Transmission of Aircraft Noise

Sound generated in air is transmitted to water primarily in a narrow area directly below the source (Appendix D, Acoustic and Explosive Concepts). A sound wave propagating from any source must enter the water at an angle of incidence of about 13° 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, 1983). 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. 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 3.0-9.

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 decibels (based on an F/A-18 aircraft flying at an altitude of 5,000 ft. and at a subsonic airspeed [400 knots] (U.S. Department of the Navy, 2016). Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead.

Helicopters

Noise generated from helicopters is transient in nature and extremely variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft (Richardson et al., 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air and is estimated to be 125 dB re 1 μPa at 1 m below water surface for a UH-60 hovering at 82 ft. (25 m) altitude (Bousman & Kufeld, 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 75-100 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. Although deviation from these guidelines may be authorized 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 (U.S. Department of the Navy, 2016). 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 (U.S. Department of the Navy & Department of Defense, 2007). 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 a boom, causing two or more wave fronts that originated from the aircraft at different times to coincide exactly (U.S. Department of the Navy, 2001). 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 sonic boom intensity. The width of the boom "carpet" or area exposed to sonic boom beneath an aircraft is about 1 mi. 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 mi. 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 (U.S. Department of the Navy & Department of Defense, 2007).

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 (U.S. Department of the Air Force, 2000). These results are shown in Table 3.0-10.

3.0.3.3.1.6 Weapon Noise

The Navy trains and tests using a variety of weapons, as described in Appendix A (Navy Activity Descriptions). Depending on the weapon, incidental (unintentional) 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 3.0.3.3.2 (Explosive Stressors).

Table 3.0-10: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

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)

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 in warning areas or special use airspace for safety reasons. Small- and medium-caliber weapons firing could occur throughout the Study Area in identified training areas.

Examples of some types of weapons noise are shown in Table 3.0-11. Examples of launch noise are provided in the table. Noise produced by other weapons and devices are described further below.

Table 3.0-11: Examples of Weapons Noise

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]

[1]Yagla and Stiegler (2003)
[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 (Figure 3.0-12). Because the muzzle blast is generated at the gun, the noise decays with distance from the gun. The muzzle blast has been measured for the largest gun analyzed in the EIS/OEIS, the 5-inch (in.) large-caliber naval gun. At a distance of 3,700 ft. from the gun, which was fired at 10° elevation angle, and at 10° off the firing line, the in-air received level was 124 dB re 20 µPa SPL peak for the atmospheric conditions of the test (U.S. Department of the Navy, 1981). Measurements were obtained for additional distances and angles off the firing line but were specific to the atmospheric conditions present during the testing.

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), most sound enters the water in a narrow cone beneath the sound source (within about 13–14° 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 in. 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 & Stiegler, 2003). The unweighted sound exposure level would be expected to be 15–20 dB lower than the peak pressure, making the highest possible sound exposure level in the water about 180–185 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.

Source: (Yagla & Stiegler, 2003)

Figure 3.0-12: Gun Blast and Projectile from a 5-in./54 Navy Gun

Large-caliber gunfire also sends energy through the ship structure and into the water. This effect was investigated in conjunction with the measurement of 5 in. gun firing described above. The energy transmitted through the ship to the water for a typical round was about 6 percent of that from the muzzle blast impinging on the water (U.S. Department of the Navy, 2000). Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise.

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). 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°) behind the projectile in the direction of fire (U.S. Department of the Navy, 1981). Exposure to the bow shock wave is very brief.

Projectiles from a 5 in./ 54 caliber gun would travel at approximately 2,600 ft./sec, and the associated bow shock wave is subjectively described as a "crack" noise (U.S. Department of the Navy, 1981). Measurements of a 5 in. projectile shock wave ranged from 140 to 147 dB re 20 µPa SPL peak taken at the ground surface at 0.59 NM distance from the firing location and 10° off the line of fire for safety (approximately 190 m from the shell's trajectory) (U.S. Department of the Navy, 1981).

Hyperkinetic projectiles may travel up to and exceed approximately six times the speed of sound in air, or about 6,500 ft./second (U.S. Department of the Navy, 2014). For a hyperkinetic projectile sized similar to the 5-in. shell, peak pressures would be expected to be several dB higher than those described for the 5-in. projectile above, following the model in U.S. Department of the Navy (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

Missiles can be rocket or jet propelled and launches typically occur far offshore or in special use airspace such as warning areas, air traffic control assigned airspace, and restricted areas. 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 3.0-11.

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, if at all, 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

The Long Range Acoustic Device is a communication device that can be used to warn vessels against continuing towards a high value asset by emitting loud sounds in air. Although not a weapon, the Long Range Acoustic Device (and other hailing and deterrent devices) is considered along with in-air sounds produced by Navy sources. The system would typically be used in training activities nearshore, 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 30–60 degree wide zone and would be directed over open water.

3.0.3.3.2 Explosive Stressors

This section describes the characteristics of explosions during naval training and testing. The activities analyzed in the EIS/OEIS that use explosives are described in Appendix A (Navy Activity Descriptions). This section provides the basis for analysis of explosive impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). Explanations of the terminology and metrics used when describing explosives in this EIS/OEIS are in Appendix D (Acoustic and Explosive Concepts).

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 (TNT), accounts for the first two parameters. The effects of these factors are explained in Appendix D (Acoustic and Explosive Concepts).

3.0.3.3.2.1 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 during training and testing 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. Section 5.3.3 (Explosive Stressors) outlines the procedural mitigation measures for explosive stressors to reduce potential impacts on biological resources.

In order to better organize and facilitate the analysis of Navy training and testing activities using explosives that could detonate in water or at the water surface, explosive classification bins were developed. The use of explosive classification bins provides the same benefits as described for acoustic source classification bins in Section 3.0.3.3.1 (Acoustic Stressors).

Explosives detonated in water are binned by net explosive weight. The bins of explosives that are proposed for use in the Study Area are shown in Table 3.0-12. This table shows the number of in-water explosive items that could be used in any year under each action alternative 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 Chapter 2 (Description of Proposed Action and Alternatives). The five-year total for both action alternatives takes any annual variability into account.

In addition to the explosives quantitatively analyzed for impacts to protected species shown in Table 3.0-12, the Navy uses some very small impulsive sources (less than 0.1 pound [lb.] net explosive weight), categorized in bin E0, that are not anticipated to result in takes of protected species. Quantitative modeling in multiple locations has validated that these sources have a very small zone of influence. These E0 charges, therefore, are categorized as *de minimis* sources and are qualitatively analyzed to determine the appropriate effects conclusions under NEPA in the appropriate resource impact analyses, as well as under the MMPA and the ESA.

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. Appendix D (Acoustic and Explosive Concepts) explains the characteristics of explosive detonations and how the above factors affect the propagation of explosive energy in the water. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the Study Area.

Table 3.0-12: Explosive Sources Quantitatively Analyzed that Could Be Used Underwater or at the Water Surface

Bin	Net Explosive Weight[1] (lb.)	Example Explosive Source	Training				Testing			
			Alternative 1		Alternative 2		Alternative 1		Alternative 2	
			Annual[2]	5-year Total	Annual[2]	5-year Total	Annual[2]	5-year Total	Annual[2]	5-year Total
E1	0.1–0.25	Medium-caliber projectile	7,700	38,500	7,700	38,500	17,840–26,840	116,200	26,840	134,200
E2	> 0.25–0.5	Medium-caliber projectile	210–214	1,062	214	1,062	0	0	0	0
E3	> 0.5–2.5	Large-caliber projectile	4,592	22,960	4,592	22,960	3,054–3,422	16,206	3,422	17,110
E4	> 2.5–5	Mine neutralization charge	127–133	653	133	653	746–800	3,784	810	4,050
E5	> 5–10	5 in. projectile	1,436	7,180	1,436	7,180	1,325	6,625	1,325	6,625
E6	> 10–20	Hellfire missile	602	3,010	602	3,010	28–48	200	48	240
E7	> 20–60	Demo block/ shaped charge	4	20	4	20	0	0	0	0
E8	> 60–100	Lightweight torpedo	22	110	22	110	33	165	33	165
E9	> 100–250	500 lb. bomb	66	330	66	330	4	20	4	20
E10	> 250–500	Harpoon missile	90	450	90	450	68–98	400	98	490
E11	> 500–650	650 lb. mine	1	5	1	5	10	50	20	100
E12	> 650–1,000	2,000 lb. bomb	18	90	18	90	0	0	0	0
E14[3]	> 1,741–3,625	Line charge	0	0	0	0	4	20	4	20
E16[4]	> 7,250–14,500	Littoral Combat Ship full ship shock trial	0	0	0	0	0–12	12	0–12	12
E17[4]	> 14,500–58,000	Aircraft carrier full ship shock trial	0	0	0	0	0–4	4	0–4	4

[1] Net Explosive Weight refers to the equivalent amount of trinitrotoluene (TNT) 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).

3.0.3.3.2.2 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 in special use airspace. Some typical types of explosive munitions that would be detonated in air during Navy activities are shown in Table 3.0-13. Various missiles, rockets, and medium- and large-caliber projectiles may be explosive or non-explosive, depending on the objective of the training or testing activity in which they are used. Quantities of explosive and non-explosive missiles, rockets, and projectiles proposed for use during Navy training and testing are provided in Appendix F (Military Expended Materials and Direct Strike Impact Analyses).

Table 3.0-13: Typical Air Explosive Munitions During Navy Activities

Weapon Type[1]	*Net Explosive Weight (lb.)*	*Typical Altitude of Detonation (ft.)*
Surface-to-Air Missile		
RIM-66 SM-2 Standard Missile	80	> 15,000
RIM-116 Rolling Airframe Missile	39	< 3,000
RIM-7 Sea Sparrow	36	> 15,000 (can be used on low targets)
FIM-92 Stinger	7	< 3,000
Air-to-Air Missile		
AIM-9 Sidewinder	38	> 15,000
AIM-7 Sparrow	36	> 15,000
AIM-120 AMRAAM	17	> 15,000
Air-to-Surface Missile		
AGM-88 HARM	45	< 100
Projectile – Large-Caliber[2]		
5"54 caliber HE -ET	7	< 100
5"54 caliber Other	8	< 3,000

[1] Mission Design Series and popular name shown for missiles. [2] Most medium and large caliber projectiles used during Navy training and testing activities do not contain high explosives.
AMRAAM = Advanced Medium-Range Air-to-Air Missile; HARM = High-Speed Anti-Radiation Missile; HE-ET = High Explosive- Electronic Time

Bombs and projectiles that detonate at or near the water surface, which are considered for underwater impacts (see Table 3.0-12), would also release some explosive energy into the air. Appendix A (Navy Activity Descriptions) describes where activities with these stressors typically occur.

The explosive energy released by detonations in air has been well-studied (see Appendix D, Acoustic and Explosive Concepts), and basic methods are available to estimate the explosive energy exposure with distance from the detonation [e.g., U.S. Department of the Navy (1975)]. 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 a sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude.

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. The casing fragments will be ejected at velocities much greater than debris from any target due to the proximity of the casing to the explosive material. Unlike detonations on land targets, in-air detonations during Navy training and testing would not result in other propelled materials such as crater debris.

3.0.3.3.3 Energy Stressors

This section describes the characteristics of energy introduced through naval training and testing activities and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts on resources from in-water electromagnetic devices, in-air electromagnetic devices, and lasers.

3.0.3.3.3.1 In-Water Electromagnetic Devices

Electromagnetic energy emitted into the water from magnetic influence mine neutralization systems is considered in this document. Table 3.0-14 shows the number and location of proposed activities, primarily mine sweeping, that include the use of in-water electromagnetic devices.

Table 3.0-14: Number and Location of Activities Including In-Water Electromagnetic Devices

Activity Area	*Maximum Annual # of Activities*		*5-Year # of Activities*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Training				
Virginia Capes Range Complex	1,203	1,203	6,015	6,015
Navy Cherry Point Range Complex	2,823	2,283	14,115	14,115
Jacksonville Range Complex	350	350	1,750	1,750
Gulf of Mexico Range Complex	104	104	480	480
Inshore Waters (Table 3.0-15)	60	60	180	180
Total	**4,540**	**4,000**	**22,540**	**22,540**
Testing				
Virginia Capes Range Complex	294	294	1,360	1,360
Navy Cherry Point Range Complex	2	2	12	12
Jacksonville Range Complex	92	92	462	462
Gulf of Mexico Range Complex	40	40	200	200
SFOMF	3	3	15	15
NSWC Panama City Testing Range	3	3	15	15
Inshore Waters (Table 3.0-15)	100	100	500	500
Total	**534**	**534**	**2,564**	**2,564**

Notes: SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-15 shows where within the inshore waters the activities would occur.

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.

Table 3.0-15: Number and Location of Activities in Inshore Waters Including In-Water Electromagnetic Devices

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	4	4	12	12
Earle, NJ	4	4	12	12
Delaware Bay, DE	4	4	12	12
Hampton Roads, VA	8	8	24	24
Morehead City, NC	4	4	12	12
Wilmington, NC	4	4	12	12
Savannah, GA	4	4	12	12
Kings Bay, GA	4	4	12	12
Mayport, FL	4	4	12	12
Port Canaveral, FL	4	4	12	12
Tampa, FL	4	4	12	12
Beaumont, TX	8	8	24	24
Corpus Christi, TX	4	4	12	12
Total	**60**	**60**	**180**	**180**
Testing				
Little Creek, VA	100	100	500	500
Total	**100**	**100**	**500**	**500**

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. These are considered safe levels for marine species due to the low electric 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[2]. This level of electromagnetic density is very low compared to magnetic fields generated by other everyday items. The magnetic field generated is between the levels of a refrigerator magnet (15,000–20,000 microteslas) and a standard household can opener (up to 400 microteslas at 4 in.). The strength of the electromagnetic field decreases quickly away from the cable. The magnetic field generated is very weak, comparable to the earth's natural field (U.S. Department of the Navy, 2005).

The kinetic energy weapon (commonly referred to as the rail gun) will be tested and eventually used in training events aboard surface vessels, firing non-explosive projectiles at land- or sea-based targets. The system uses stored electrical energy to accelerate the projectiles, which are fired at supersonic speeds over great distances. The system charges for two minutes, and fires in less than one second; therefore, the release of any electromagnetic energy would occur over a very short period. Also, the system is shielded so as not to affect shipboard controls and systems. The amount of electromagnetic energy

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

released from this system is low and contained on the surface vessel. Therefore, this device is not expected to result in any electromagnetic impacts and will not be further analyzed for biological resources in this document.

3.0.3.3.3.2 In-Air Electromagnetic Devices

Sources of electromagnetic energy in the air include kinetic energy weapons, communications transmitters, radars, and electronic countermeasures 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 (MHz) to 14,500 MHz, and transmitter maximum average power may range from 0.25 watts to 1,280,00 watts.

The term radar was originally coined by the Navy to refer to Radio Detection And Ranging. 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 & 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 (Courbis & Timmel, 2008). In general, radars operate at radio frequencies that range between 300 MHz 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., 2016).

It is assumed that most Navy platforms associated with the Proposed Action will be transmitting from a variety of in-air electromagnetic devices at all times that 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. The number of Navy vessels or aircraft in the Study Area at any given time varies and is dependent on local training or testing requirements. Therefore, in-air electromagnetic energy as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the Study Area near ports, naval installations, and range complexes. Table 3.0-18 and Table 3.0-36 show the annual number and location of activities involving vessels and aircraft, which provide a proxy for level of in-air electromagnetic device use for the purposes of this EIS/OEIS.

3.0.3.3.3.3 Lasers

The devices discussed here include lasers that can be organized into two categories: (1) low-energy lasers and (2) high-energy 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 on air and surface targets.

Low-Energy Lasers

Within the category of low-energy lasers, the highest potential level of exposure would be from an underwater laser or an airborne laser beam directed at the ocean's surface. An assessment on the use of low-energy lasers by the Navy determined that low-energy lasers, including those involved in the training and testing activities in this EIS/OEIS, have an extremely low potential to impact marine biological resources (U.S. Department of the Navy, 2010). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (U.S. Department of the Navy, 2010). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich, 2004). Based on the parameters of the low-energy lasers and the behavior and life history of major biological groups, it was determined the greatest potential for impact would be to the eye of a marine species. However, an animal's eye would have to be exposed to a direct laser beam for at least ten seconds to sustain damage. U.S. Department of the Navy (2010) assessed the potential for damage based on species specific eye/vision parameters and the anticipated output from low-energy lasers, and determined that no animals were predicted to incur damage. Therefore, low-energy lasers are not further analyzed in this document for biological resources.

High-Energy Lasers

High-energy laser 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. High-energy lasers would be employed from surface ships and are designed to create small but critical failures in potential targets. The high-energy laser is expected to be used at short ranges. Table 3.0-16 shows the number and location of proposed activities that include the use of high-energy lasers. Marine life at or near the ocean surface and birds could be susceptible to injury by high-energy lasers.

Table 3.0-16: Number and Location of Activities Including High-Energy Lasers

Activity Area	*Maximum Annual # of Activities*		*5-Year # of Activities*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Training				
Virginia Capes Range Complex	4	4	20	20
Jacksonville Range Complex	4	4	20	20
Total	**8**	**8**	**40**	**40**
Testing				
Northeast Range Complexes	8	8	26	26
Virginia Capes Range Complex	116	116	565	565
Navy Cherry Point Range Complex	8	8	26	26
Jacksonville Range Complex	8	8	26	26
Key West Range Complex	8	8	26	26
Gulf of Mexico Range Complex	8	8	26	26
NUWC Newport Testing Range	8	8	26	26
SFOMF	8	8	26	26
NSWC Panama City Testing Range	8	8	26	26
Total	**180**	**180**	**773**	**773**

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

3.0.3.3.4 Physical Disturbance and Strike Stressors

This section describes the characteristics of physical disturbance and strike stressors from Navy training and testing activities. It also describes the magnitude and location of these activities to provide the basis for analyzing the potential physical disturbance and strike impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences).

3.0.3.3.4.1 Vessels and In-Water Devices

Vessels

Vessels used as part of the Proposed Action include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 ft. to over 1,000 ft. Table 3.0-17 provides examples of the types of vessels, length, and speeds used in both testing and training activities. The U.S. Navy Fact Files, available on the Internet at http://www.navy.mil/navydata/fact.asp, provide the latest information on the quantity and specifications of the vessels operated by the Navy.

Table 3.0-17: Representative Vessel Types, Lengths, and Speeds

Type	*Example(s)*	*Length*	*Typical Operating Speed*
Aircraft Carrier	Aircraft Carrier (CVN)	>1,000 ft.	10–15 knots
Surface Combatant	Cruisers (CG), Destroyers (DDG), 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

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 10–15 knots, and submarines generally operate at speeds in the range of 8–13 knots. Small craft (for purposes of this discussion, less than 50 ft. in length), which are all support craft, have much more variable speeds (0–50 knots or greater, 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-offs 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.

The number of Navy vessels in the Study 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. For the purposes of this analysis, vessel movements are discussed in two categories; (1) those activities that occur in the offshore component of the Study Area and (2) those activities that occur in inshore waters.

Activities that occur in the offshore component of the Study 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 Study 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, and can involve speeds greater than 10 knots. The vessels operating within the inshore waters are generally smaller than those in the offshore waters and are considered small craft (less than 50 ft.).

In an attempt to determine traffic patterns for Navy and non-Navy vessels, the Center for Naval Analysis (Mintz & 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. Compared to coastal vessel activity, there was relatively little concentration of vessels in the other portions of the Study Area (Mintz & Parker, 2006). Navy traffic was heaviest just offshore of Norfolk, Virginia, and Jacksonville, Florida, as well as along the coastal waters between the two ports.

Data collected for 2009 vessel traffic were analyzed by Mintz (2012) and Mintz and Filadelfo (2011) and indicated that within the AFTT Study Area, large Navy vessels accounted for less than 1 percent of the total large vessel traffic (from estimated vessel hours using positional data) in that area. In the Virginia Capes and Jacksonville Range Complexes where Navy vessel activity is concentrated, the Navy vessels accounted for 7 and 9 percent (respectively) of the total large vessel traffic. Barco et al. (2009) found that large military vessels (at least 65 ft. in length) were approximately 18 percent of the total large vessels transiting (inbound and outbound) the Chesapeake Bay channel, an area of highly concentrated Navy activity because of the proximity of Naval Station Norfolk. Based on the large number of commercial and recreational boats in the Hampton Roads area, military vessels would probably comprise an even smaller proportion of total vessels, if smaller vessels (less than 65 ft. in length) were factored into these analyses.

Table 3.0-18 shows the number and location of proposed activities that include the use of vessels in the Study Area. Each activity included in Table 3.0-18 could involve one or more vessels. As described above in Section 3.0.3.3 (Identifying Stressors for Analysis), activities are not always conducted independently of each other, as there are instances when a training activity could occur on a vessel while another training activity or a testing activity is being conducted on the same vessel simultaneously. 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 3.0-19 shows the number and location of proposed activities that include the use of vessels in the inshore waters of the Study Area. Each activity included in Table 3.0-19 could involve one or more vessels.

Table 3.0-18: Number and Location of Activities Including Vessels

Activity Area	*Maximum Annual # of Activities*		*5-Year # of Activities*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Training				
Northeast Range Complexes	411	416	2,055	2,080
Virginia Capes Range Complex	12,412	12,632	62,019	63,158
Navy Cherry Point Range Complex	6,754	6,809	33,693	34,043
Jacksonville Range Complex	10,841	11,281	54,112	56,405
Key West Range Complex	131	131	655	655
Gulf of Mexico Range Complex	771	807	3,855	4,035
Other AFTT Areas	691	709	3,435	3,525
Inshore Waters (see Table 3.0-19)	4,197	4,197	20,935	20,935
Total	**36,208**	**36,982**	**180,579**	**184,836**
Testing				
Northeast Range Complexes	1,088	1,094	4,877	5,458
Virginia Capes Range Complex	1,784	1,786	7,388	8,786
Navy Cherry Point Range Complex	791	793	3,947	3,963
Jacksonville Range Complex	1,298	1,308	6,096	6,360
Key West Range Complex	398	398	1,732	1,936
Gulf of Mexico Range Complex	618	618	2,979	3,026
NUWC Newport Testing Range	767	767	3,803	3,830
SFOMF	198	198	992	992
NSWC Panama City Testing Range	406	406	2,003	2,003
Inshore Waters (see Table 3.0-19)	216	216	1,078	1,078
Total	**7,564**	**7,584**	**34,895**	**37,432**

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-19: Number and Location of Activities in Inshore Waters Including Vessels

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	2	2	6	6
Groton, CT	235	235	1,175	1,175
Narragansett, RI	198	198	990	990
Earle, NJ	2	2	6	6
Delaware Bay, DE	2	2	6	6
James River & Tributaries, VA	830	830	4,200	4,200
York River, VA	129	129	645	645
Lower Chesapeake Bay, VA	1,697	1,697	8,485	8,485
Hampton Roads, VA	4	4	12	12
Norfolk, VA	515	515	2,575	2,575
Morehead City, NC	2	2	6	6
Wilmington, NC	2	2	6	6
Cooper River, SC	120	120	600	600
Savannah, GA	2	2	6	6
Kings Bay, GA	7	7	31	31
Mayport, FL	343	343	1,711	1,711
St. Johns River, FL	2	2	10	10
Port Canaveral, FL	47	47	231	231
Tampa, FL	2	2	6	6
St. Andrew Bay, FL	50	50	250	250
Beaumont, TX	4	4	12	12
Corpus Christi, TX	2	2	6	6
Total	**4,197**	**4,197**	**20,975**	**20,975**
Testing				
Bath, ME	11	11	55	55
Portsmouth, NH	26	26	130	130
Newport, RI	4	4	20	20
Groton, CT	9	9	47	47
Little Creek, VA	61	61	301	301
Norfolk, VA	64	64	318	318
Kings Bay, GA	4	4	20	20
Mayport, FL	27	27	135	135
Port Canaveral, FL	3	3	17	17
Pascagoula, MS	7	7	35	35
Total	**216**	**216**	**1,078**	**1,078**

As stated earlier, activities that include vessel movements in the inshore waters of the Study 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 appropriately, the number of hours of high-speed vessel movement for small craft are provided in Table 3.0-20.

Table 3.0-20: Number of High Speed Vessel Hours for Small Craft Associated with Training Activities in Inshore Waters of the Study Area

	Maximum Annual # of Hours		*5-Year # of Hours*	
Activity Area	***Alternative 1***	***Alternative 2***	***Alternative 1***	***Alternative 2***
Narragansett, RI	9,502	9,502	47,510	47,510
James River & Tributaries	18,108	18,108	90,540	90,540
York River	6,590	6,590	32,950	32,950
Lower Chesapeake Bay	39,325	39,325	196,625	196,625
Cooper River, SC	12,651	12,651	63,255	63,255
Mayport, FL	510	510	2,550	2,550
St. Johns River	482	482	2,410	2,410
Port Canaveral, FL	4,352	4,352	21,760	21,760
St. Andrew Bay	56	56	280	280
Total	**91,576**	**91,576**	**457,880**	**457,880**

While the estimates provided in the above tables 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 manner in which the Navy uses vessels to accomplish its training and testing activities is likely to remain consistent with the range of variability observed over the last decade.

In-Water Devices

In-water devices as discussed in this analysis 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 3.0-21 for a range of in-water devices 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. Because of their size and potential operating speed, unmanned surface vehicles are the in-water devices that operate in a manner with the most potential to strike living marine resources. Table 3.0-22 shows the number and location of proposed activities that include the use of in-water devices. For a list of activities by name that include the use of in-water devices, see Appendix B (Activity Stressor Matrices).

Table 3.0-21: Representative Types, Sizes, and Speeds of In-Water Devices

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

Table 3.0-22: Number and Location of Activities Including In-Water Devices

Activity Area	*Maximum Annual # of Activities*		*5-Year # of Activities*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Training				
Northeast Range Complexes	135	139	671	695
Virginia Capes Range Complex	7,316	7,556	36,538	37,780
Navy Cherry Point Range Complex	2,027	2,091	10,053	10,455
Jacksonville Range Complex	5,097	5,621	25,356	28,385
Key West Range Complex	32	32	160	160
Gulf of Mexico Range Complex	724	768	3,616	3,840
NSWC Panama City Testing Range	328	328	1,640	1,640
Other AFTT Areas	362	362	1,800	1,800
Inshore Waters (see Table 3.0-23)	1,217	1,217	6,335	6,335
Total	**17,238**	**18,114**	**86,169**	**91,090**
Testing				
Northeast Range Complexes	450	451	1,774	2,240
Virginia Capes Range Complex	1,266	1,266	5,084	6,332
Navy Cherry Point Range Complex	137	138	679	687
Jacksonville Range Complex	800	801	3,681	3,931
Key West Range Complex	111	111	328	544
Gulf of Mexico Range Complex	322	322	1,521	1,607
NUWC Newport Testing Range	1,032	1,032	5,147	5,147

Table 3.0-22: Number and Location of Activities Including In-Water Devices (continued)

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Testing				
SFOMF	204	204	1,014	1,014
NSWC Panama City Testing Range	438	438	2,047	2,111
Total	**4,760**	**4,763**	**21,275**	**23,613**

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-23: Number and Location of Activities in Inshore Waters Including In-Water Devices

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	7	7	21	21
Earle, NJ	7	7	21	21
Delaware Bay, DE	7	7	21	21
Lower Chesapeake Bay	852	852	4,260	4,260
Hampton Roads, VA	14	14	42	42
James River and Tributaries	108	108	1,000	1,000
York River	38	38	190	190
Morehead City, NC	7	7	21	21
Wilmington, NC	7	7	21	21
Savannah, GA	7	7	21	21
Kings Bay, GA	51	51	241	241
Mayport, FL	77	77	371	371
Port Canaveral, FL	7	7	21	21
Tampa, FL	7	7	21	21
Beaumont, TX	14	14	42	42
Corpus Christi, TX	7	7	21	21
Total	**1,217**	**1,217**	**6,335**	**6,335**

3.0.3.3.4.2 Military Expended Materials

Military expended materials that may cause physical disturbance or strike include: (1) all sizes of non-explosive practice munitions (Table 3.0-24, Table 3.0-25 and Table 3.0-26), (2) fragments from high-explosive munitions (Table 3.0-27 and Table 3.0-28), (3) expendable targets (Table 3.0-29, Table 3.0-30, and Table 3.0-31), and (4) expended materials other than munitions, such as sonobuoys or torpedo accessories (Table 3.0-32, Table 3.0-33, and Table 3.0-34). See Appendix F (Military Expended Materials and Direct Strike Impact Analyses) for more information on the type and quantities of military expended materials proposed to be used.

For living marine resources in the water column, the discussion of military expended material strikes focuses on the potential of a strike at the surface of the water. The effect of materials settling on the bottom will be discussed as an alteration of the bottom substrate and associated organisms (e.g., invertebrates and vegetation).

Table 3.0-24: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Torpedoes [1]				
Northeast Range Complexes	24	24	120	120
Virginia Capes Range Complex	21	21	105	105
Jacksonville Range Complex	92	92	460	460
Total	**137**	**137**	**685**	**685**
Bombs				
Virginia Capes Range Complex	2,188	2,188	10,940	10,940
Navy Cherry Point Range Complex	596	596	2,980	2,980
Jacksonville Range Complex	1,360	1,360	6,800	6,800
Gulf of Mexico Range Complex	270	270	1,350	1,350
Total	**4,414**	**4,414**	**22,070**	**22,070**
Rockets				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	1,835	1,183	9,175	9,175
Navy Cherry Point Range Complex	304	304	1,520	1,520
Jacksonville Range Complex	2,095	2,095	10,474	10,474
Gulf of Mexico Range Complex	191	191	955	955
Total	**4,426**	**3,774**	**22,129**	**22,129**
Rockets (Flechette)				
Virginia Capes Range Complex	95	95	475	475
Jacksonville Range Complex	110	110	551	551
Total	**205**	**205**	**1,026**	**1,026**
Large-Caliber Projectiles				
Virginia Capes Range Complex	4,930	4,930	24,650	24,650
Navy Cherry Point Range Complex	1,234	1,234	6,170	6,170
Jacksonville Range Complex	2,534	2,534	12,670	12,670
Gulf of Mexico Range Complex	498	498	2,490	2,490
Other AFTT Areas	210	210	1,050	1,050
Total	**9,406**	**9,406**	**47,030**	**47,030**
Large-Caliber – Casings Only				
Navy Cherry Point Range Complex	1,040	1,040	2,800	2,800
Total	**1,040**	**1,040**	**2,800**	**2,800**

Table 3.0-24: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Medium-Caliber Projectiles				
Northeast Range Complexes	1,000	1,000	5,000	5,000
Virginia Capes Range Complex	658,561	658,561	3,292,805	3,292,805
Navy Cherry Point Range Complex	328,149	328,149	1,640,745	1,640,745
Jacksonville Range Complex	383,861	383,861	1,919,305	1,919,305
Key West Range Complex	28,000	28,000	140,000	140,000
Gulf of Mexico Range Complex	28,950	28,950	144,750	144,750
Other AFTT Areas	21,150	21,150	100,750	100,750
Total	**1,449,671**	**1,449,671**	**7,243,355**	**7,243,355**
Small-Caliber Projectiles				
Northeast Range Complexes	27,000	27,000	135,000	135,000
Virginia Capes Range Complex	2,262,000	2,262,000	11,310,000	11,310,000
Navy Cherry Point Range Complex	393,000	393,000	1,965,000	1,965,000
Jacksonville Range Complex	1,026,000	1,026,000	5,130,000	5,130,000
Gulf of Mexico Range Complex	83,000	83,000	415,000	415,000
Other AFTT Areas	100,000	100,000	500,000	500,000
Total	**3,891,000**	**3,891,000**	**19,455,000**	**19,455,000**
Small-Caliber – Casings Only				
Virginia Capes Range Complex	5,000	5,000	25,000	25,000
Jacksonville Range Complex	5,000	5,000	25,000	25,000
Inshore Waters (see Table 3.0-25)	202,140	202,140	1,010,700	1,010,700
Total	**212,140**	**212,140**	**1,060,700**	**1,060,700**
Kinetic Energy Round				
Virginia Capes Range Complex	32	32	160	160
Navy Cherry Point Range Complex	4	4	20	20
Jacksonville Range Complex	4	4	20	20
Gulf of Mexico Range Complex	4	4	20	20
Other AFTT Areas	4	4	20	20
Total	**48**	**48**	**240**	**240**

[1] Non-explosive torpedoes are recovered after use.
Notes: AFTT = Atlantic Fleet Training and Testing

Table 3.0-25: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities in Inshore Waters

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Small-Caliber – Casings Only				
Narragansett, RI	8,320	8,320	41,600	41,600
James River & Tributaries	97,920	97,920	489,600	489,600
Lower Chesapeake Bay	78,000	78,000	390,000	390,000
Cooper River, SC	5,100	5,100	25,500	25,500
Port Canaveral, FL	12,800	12,800	64,000	64,000
Total	**202,140**	**202,140**	**1,010,700**	**1,010,700**

Table 3.0-26: Number and Location of Non-Explosive Practice Munitions Expended During Testing Activities

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Torpedoes [1]				
Northeast Range Complexes	146	146	661	709
Virginia Capes Range Complex	375	375	1,571	1,862
Navy Cherry Point Range Complex	118	118	591	591
Jacksonville Range Complex	369	369	1,673	1,790
Key West Range Complex	2	2	11	11
Gulf of Mexico Range Complex	132	132	611	659
NUWC Newport Testing Range	315	315	1,575	1,575
SFOMF	6	6	29	29
NSWC Panama City Testing Range	180	180	900	900
Total	**1,643**	**1,643**	**7,622**	**8,126**
Bombs				
Virginia Capes Range Complex	916	916	4,580	4,580
Jacksonville Range Complex	12	12	60	60
Total	**928**	**928**	**4,460**	**4,460**
Rockets				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	759	759	3,713	3,727
Jacksonville Range Complex	407	407	1,950	2,034
Gulf of Mexico Range Complex	1	1	5	5
Total	**1,168**	**1,168**	**5,673**	**5,771**
Rockets (Flechette)				
Virginia Capes Range Complex	249	249	1,215	1,243
Jacksonville Range Complex	136	136	648	676
Total	**385**	**385**	**1,863**	**1,919**

Table 3.0-26: Number and Location of Non-Explosive Practice Munitions Expended During Testing Activities (continued)

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Missiles				
Northeast Range Complexes	25	25	122	122
Virginia Capes Range Complex	1,633	1,633	3,962	3,994
Navy Cherry Point Range Complex	25	25	122	122
Jacksonville Range Complex	594	594	814	822
Key West Range Complex	32	32	157	157
Gulf of Mexico Range Complex	42	42	207	207
Total	**2,351**	**2,351**	**5,384**	**5,424**
Kinetic Energy Rounds				
Northeast Range Complexes	33,503	33,503	167,504	167,504
Virginia Capes Range Complex	35,003	35,003	167,504	167,504
Navy Cherry Point Range Complex	35,003	35,003	167,504	167,504
Jacksonville Range Complex	35,003	35,003	167,504	167,504
Key West Range Complex	35,003	35,003	167,504	167,504
Gulf of Mexico Range Complex	35,003	35,003	167,504	167,504
NUWC Newport Testing Range	4	4	4	4
SFOMF	4	4	4	4
NSWC Panama City Testing Range	4	4	4	4
Total	**208,530**	**208,530**	**1,005,036**	**1,005,036**
Large-Caliber Projectiles				
Northeast Range Complexes	1,761	1,761	8,805	8,805
Virginia Capes Range Complex	8,147	8,147	40,735	40,735
Navy Cherry Point Range Complex	1,440	1,440	7,200	7,200
Jacksonville Range Complex	14,524	14,524	72,620	72,620
Key West Range Complex	3,190	3,190	15,950	15,950
Gulf of Mexico Range Complex	2,774	2,774	13,870	13,870
NSWC Panama City Testing Range	280	280	1,400	1,400
Total	**32,116**	**32,116**	**160,580**	**160,580**
Medium-Caliber Projectiles				
Northeast Range Complexes	9,060	9,060	45,300	45,300
Virginia Capes Range Complex	234,665	234,665	1,155,325	1,173,325
Navy Cherry Point Range Complex	8,160	8,160	40,800	40,800
Jacksonville Range Complex	237,360	237,360	1,150,800	1,186,800
Key West Range Complex	32,660	32,660	163,300	163,300
Gulf of Mexico Range Complex	22,860	22,860	114,300	114,300
NSWC Panama City Testing Range	5,100	5,100	25,500	25,500
Total	**549,865**	**549,865**	**2,695,325**	**2,749,325**

Table 3.0-26: Number and Location of Non-Explosive Practice Munitions Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Small-Caliber Projectiles				
Northeast Range Complexes	4,800	4,800	24,000	24,000
Virginia Capes Range Complex	77,800	77,800	389,000	389,000
Navy Cherry Point Range Complex	4,800	4,800	24,000	24,000
Jacksonville Range Complex	4,800	4,800	24,000	24,000
Key West Range Complex	4,800	4,800	24,000	24,000
Gulf of Mexico Range Complex	17,800	17,800	89,000	89,000
NSWC Panama City Testing Range	7,000	7,000	35,000	35,000
Total	**121,800**	**121,800**	**609,000**	**609,000**

[1] Non-explosive torpedoes are recovered after use.

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-27: Number and Location of Explosives that May Result in Fragments Used During Training Activities

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Torpedoes				
SINKEX Area	1	1	5	5
Total	**1**	**1**	**5**	**5**
Neutralizers				
Virginia Capes Range Complex	62	62	306	306
Navy Cherry Point Range Complex	1	1	5	5
Jacksonville Range Complex	2	2	6	6
Gulf of Mexico Range Complex	22	22	106	106
Total	**87**	**87**	**423**	**423**
Grenades				
Northeast Range Complexes	56	56	280	280
Virginia Capes Range Complex	4,070	4,070	20,350	20,350
Navy Cherry Point Range Complex	28	28	140	140
Jacksonville Range Complex	28	28	140	140
Gulf of Mexico Range Complex	28	28	140	140
Total	**4,210**	**4,210**	**21,050**	**21,050**
Bombs				
Virginia Capes Range Complex	88	88	500	500
Jacksonville Range Complex	56	56	280	280
Gulf of Mexico Range Complex	4	4	20	20

Table 3.0-27: Number and Location of Explosives that May Result in Fragments Used During Training Activities (continued)

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
SINKEX Area	12	12	60	60
Total	**160**	**160**	**860**	**860**
Rockets				
Virginia Capes Range Complex	1,748	1,748	8,740	8,740
Navy Cherry Point Range Complex	76	76	380	380
Jacksonville Range Complex	1,824	1,824	9,120	9,120
Gulf of Mexico Range Complex	190	190	950	950
Total	**3,838**	**3,838**	**19,190**	**19,190**
Missiles				
Northeast Range Complexes	2	2	10	10
Virginia Capes Range Complex	199	199	995	995
Navy Cherry Point Range Complex	187	187	935	935
Jacksonville Range Complex	192	192	960	960
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	2	2	10	10
SINKEX Area	4	4	20	20
Total	**594**	**594**	**2,970**	**2,970**
Large-Caliber Projectiles				
Virginia Capes Range Complex	762	762	3,180	3,180
Navy Cherry Point Range Complex	210	210	1,050	1,050
Jacksonville Range Complex	642	642	3,210	3,210
Gulf of Mexico Range Complex	114	114	570	570
Other AFTT Areas	114	114	570	570
SINKEX Area	200	200	1,000	1,000
Total	**2,042**	**2,042**	**9,580**	**9,580**
Medium-Caliber Projectiles				
Virginia Capes Range Complex	46,100	46,100	230,500	230,500
Navy Cherry Point Range Complex	20,000	20,000	100,000	100,000
Jacksonville Range Complex	45,600	45,600	228,000	228,000
Gulf of Mexico Range Complex	6,000	6,000	30,000	30,000
Other AFTT Areas	400	400	2,000	2,000
Total	**118,100**	**118,100**	**590,500**	**590,500**

Notes: AFTT = Atlantic Fleet Training and Testing; SINKEX = Sinking Exercise

Table 3.0-28: Number and Location of Explosives that May Result in Fragments Used During Testing Activities

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Torpedoes				
Northeast Range Complexes	7	7	29	29
Virginia Capes Range Complex	7	7	29	29
Navy Cherry Point Range Complex	3	3	9	9
Jacksonville Range Complex	7	7	29	29
Key West Range Complex	3	3	9	9
Gulf of Mexico Range Complex	7	7	29	29
NSWC Panama City Testing Range	12	12	60	60
Total	**46**	**46**	**194**	**194**
Explosive Sonobuoys				
Key West Range Complex	36	36	180	180
Total	**36**	**36**	**180**	**180**
AMNS Neutralizers				
Virginia Capes Range Complex	250	255	1,090	1,275
Jacksonville Range Complex	50	50	250	250
Gulf of Mexico Range Complex	100	100	500	500
NSWC Panama City Testing Range	328	333	1,584	1,665
Total	**728**	**738**	**3,424**	**3,690**
Bombs				
Virginia Capes Range Complex	4	4	20	20
Total	**4**	**4**	**20**	**20**
Rockets				
Virginia Capes Range Complex	206	206	830	1,030
Jacksonville Range Complex	200	200	800	1,000
Total	**406**	**406**	**1,630**	**2,030**
Missiles				
Northeast Range Complexes	10	10	50	50
Virginia Capes Range Complex	222	222	1,033	1,110
Jacksonville Range Complex	70	70	327	350
Gulf of Mexico Range Complex	12	12	30	60
Total	**314**	**314**	**1,440**	**1,570**
Buoys				
Northeast Range Complexes	736	736	3,680	3,680
Virginia Capes Range Complex	368	368	1,840	1,840
Navy Cherry Point Range Complex	152	152	760	760
Jacksonville Range Complex	152	152	760	760
Key West Range Complex	202	202	1,010	1,010
Gulf of Mexico Range Complex	368	368	1,840	1,840
Total	**1,978**	**1,978**	**9,890**	**9,890**

Table 3.0-28: Number and Location of Explosives that May Result in Fragments Used During Testing Activities (continued)

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Anti-Torpedo Countermeasures				
Northeast Range Complexes	78	78	330	378
Virginia Capes Range Complex	96	96	432	480
Navy Cherry Point Range Complex	36	36	180	180
Jacksonville Range Complex	104	104	448	496
Gulf of Mexico Range Complex	72	72	312	360
Total	**386**	**386**	**1,702**	**1,894**
Mines				
Virginia Capes Range Complex	2	7	10	35
NSWC Panama City Testing Range	4	9	20	45
Total	**6**	**16**	**30**	**80**
Large-Caliber Projectiles				
Northeast Range Complexes	1,632	1,632	8160	8160
Virginia Capes Range Complex	4,763	4,763	23,815	23,815
Navy Cherry Point Range Complex	1,632	1,632	8,160	8,160
Jacksonville Range Complex	7,876	7,876	39,380	39,380
Key West Range Complex	2,332	2,332	11,660	11,660
Gulf of Mexico Range Complex	2,243	2,243	12,115	12,115
NSWC Panama City Testing Range	280	280	500	500
Total	**20,758**	**20,758**	**103,790**	**103,790**
Medium-Caliber Projectiles				
Northeast Range Complexes	3,860	3,860	19,300	19,300
Virginia Capes Range Complex	17,270	17,270	80,350	86,350
Navy Cherry Point Range Complex	3,360	3,360	16,800	16,800
Jacksonville Range Complex	14,860	14,860	62,300	74,300
Key West Range Complex	3,360	3,360	16,800	16,800
Gulf of Mexico Range Complex	3,360	3,360	16,800	16,800
Total	**46,070**	**46,070**	**212,350**	**230,350**

Notes: NSWC = Naval Surface Warfare Center

Table 3.0-29: Number and Location of Targets Expended During Training Activities

Activity Area	*Maximum Annual # of Targets*		*5-Year # of Targets*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Air Targets (Decoy)				
Northeast Range Complexes	2	2	10	10
Virginia Capes Range Complex	81	81	405	405
Navy Cherry Point Range Complex	52	52	260	260
Jacksonville Range Complex	61	61	305	305
Key West Range Complex	9	9	47	47
Gulf of Mexico Range Complex	2	2	10	10
Total	**207**	**207**	**1,037**	**1,037**
Air Targets (Drone)				
Northeast Range Complexes	0	0	2	2
Virginia Capes Range Complex	18	18	92	92
Navy Cherry Point Range Complex	28	28	138	138
Jacksonville Range Complex	7	7	34	34
Gulf of Mexico Range Complex	0	0	2	2
Key West Range Complex	2	2	8	8
Total	**55**	**55**	**276**	**276**
Surface Targets (Mobile)				
Virginia Capes Range Complex	70	70	348	348
Navy Cherry Point Range Complex	23	23	114	114
Jacksonville Range Complex	78	78	388	388
Gulf of Mexico Range Complex	3	3	12	12
Total	**174**	**174**	**862**	**862**
Surface Targets (Stationary)				
Northeast Range Complexes	20	20	100	100
Virginia Capes Range Complex	4,512	4,512	22,560	22,560
Navy Cherry Point Range Complex	1,298	1,298	6,490	6,490
Jacksonville Range Complex	3,013	3,013	15,065	15,065
Gulf of Mexico Range Complex	334	334	1,670	1,670
Other AFTT Areas	200	200	980	980
Total	**9,377**	**9,377**	**46,865**	**46,865**
Subsurface Targets (Mobile)				
Northeast Range Complexes	82	84	408	420
Virginia Capes Range Complex	304	414	1,520	2,070
Navy Cherry Point Range Complex	98	125	488	625
Jacksonville Range Complex	1,057	1,272	5,303	6,362
Gulf of Mexico Range Complex	3	5	13	25
Other AFTT Areas	134	134	670	670
Total	**1,678**	**2,034**	**8,402**	**10,172**

Table 3.0-29: Number and Location of Targets Expended During Training Activities (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Mine Shapes				
Virginia Capes Range Complex	221	221	1,105	1,105
Navy Cherry Point Range Complex	78	78	390	390
Jacksonville Range Complex	78	78	390	390
Key West Range Complex	2	2	8	8
Gulf of Mexico Range Complex	93	93	466	466
Inshore Waters (see Table 3.0-30)	2	2	8	8
Total	**474**	**474**	**2,367**	**2,367**
Ship Hulks				
SINKEX Area	1	1	5	5
Total	**1**	**1**	**5**	**5**

Notes: AFTT = Atlantic Fleet Training and Testing; SINKEX = Sinking Exercise

Table 3.0-30: Number and Location of Targets Expended During Training Activities in Inshore Waters

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Mine Shapes				
Lower Chesapeake Bay	2	2	8	8
Total	**2**	**2**	**8**	**8**

Table 3.0-31: Number and Location of Targets Expended During Testing Activities

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Air Targets (Drones)				
Northeast Range Complexes	6	6	28	28
Virginia Capes Range Complex	200	200	976	976
Navy Cherry Point Range Complex	8	8	8	8
Jacksonville Range Complex	62	62	286	286
Key West Range Complex	6	6	6	6
Gulf of Mexico Range Complex	16	16	56	56
NUWC Newport Testing Range	6	6	6	6
SFOMF	6	6	6	6
NSWC Panama City Testing Range	6	6	6	6
Total	**316**	**316**	**1,378**	**1,378**
Air Targets (Decoy)				
Virginia Capes Range Complex	5	5	22	22
Jacksonville Range Complex	2	2	6	6
Total	**7**	**7**	**28**	**28**

Table 3.0-31: Number and Location of Targets Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Surface Targets (Mobile)				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	153	153	763	764
Jacksonville Range Complex	19	19	96	96
Key West Range Complex	2	2	11	11
Gulf of Mexico Range Complex	2	2	11	11
NUWC Newport Testing Range	450	450	2,250	2,250
Total	**627**	**627**	**3,136**	**3,137**
Surface Targets (Stationary)				
Northeast Range Complexes	172	172	858	858
Virginia Capes Range Complex	832	832	4,015	4,160
Navy Cherry Point Range Complex	172	172	858	858
Jacksonville Range Complex	545	545	2,576	2,727
Key West Range Complex	178	178	890	890
Gulf of Mexico Range Complex	248	248	1,212	1,242
NUWC Newport Testing Range	484	484	2,421	2,421
SFOMF	56	56	282	282
Total	**2,687**	**2,687**	**13,112**	**13,438**
Sub-Surface Targets (Mobile)				
Northeast Range Complexes	54	55	198	272
Virginia Capes Range Complex	57	58	237	290
Navy Cherry Point Range Complex	7	8	32	40
Jacksonville Range Complex	184	184	867	917
Key West Range Complex	3	3	15	15
Gulf of Mexico Range Complex	208	208	983	1,040
NUWC Newport Testing Range	516	516	2,581	2,581
SFOMF	95	95	475	475
Total	**1,124**	**1,127**	**5,388**	**5,630**
Sub-Surface Targets (Stationary)				
Northeast Range Complexes	2,228	2,228	10,896	11,142
Virginia Capes Range Complex	1,142	1,142	5,260	5,709
Navy Cherry Point Range Complex	81	81	407	407
Jacksonville Range Complex	320	320	1,564	1,600
Key West Range Complex	32	32	38	134
Gulf of Mexico Range Complex	960	960	4,795	4,801
NUWC Newport Testing Range	374	374	1,868	1,868
SFOMF	84	84	419	419
Total	**5,221**	**5,221**	**25,247**	**26,080**

Table 3.0-31: Number and Location of Targets Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Mine Shapes				
Virginia Capes Range Complex	127	127	536	636
Jacksonville Range Complex	122	122	610	610
Gulf of Mexico Range Complex	232	232	1,158	1,158
SFOMF	40	40	200	200
NSWC Panama City Testing Range	370	370	1,815	1,850
Total	**891**	**891**	**4,319**	**4,454**

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Acoustic Countermeasures				
Northeast Range Complexes	84	84	420	420
Virginia Capes Range Complex	51	51	255	255
Navy Cherry Point Range Complex	24	24	120	120
Jacksonville Range Complex	184	184	902	920
Gulf of Mexico Range Complex	0	6	0	30
Other AFTT Areas	88	88	440	440
Total	**431**	**437**	**2,137**	**2,185**
Compression Pad/Piston				
Virginia Capes Range Complex	1,000	1,000	5,000	5,000
Navy Cherry Point Range Complex	22,300	22,300	111,500	111,500
Jacksonville Range Complex	38,000	38,000	190,000	190,000
Key West Range Complex	31,000	31,000	155,000	155,000
Gulf of Mexico Range Complex	1,840	1,840	9,200	9,200
Inshore Waters (see Table 3.0.33)	20,400	20,400	102,000	102,000
Total	**114,540**	**114,540**	**572,700**	**572,700**
Chaff – Air Cartridge				
Virginia Capes Range Complex	2,080	2,080	10,400	10,400
Navy Cherry Point Range Complex	25,760	25,760	128,800	128,800
Jacksonville Range Complex	47,840	47,840	239,200	239,200
Key West Range Complex	4,800	4,800	240,000	240,000
Gulf of Mexico Range Complex	288	288	1,440	1,440
Total	**80,768**	**80,768**	**619,840**	**619,840**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Chaff – Ship Cartridge				
Virginia Capes Range Complex	264	264	1,320	1,320
Navy Cherry Point Range Complex	480	480	2,400	2,400
Jacksonville Range Complex	516	516	2,580	2,580
Gulf of Mexico Range Complex	120	120	600	600
Total	**1,380**	**1,380**	**6,900**	**6,900**
Endcaps – Chaff & Flare				
Virginia Capes Range Complex	3,120	3,120	15,600	15,600
Navy Cherry Point Range Complex	48,108	48,108	240,540	240,540
Jacksonville Range Complex	85,888	85,888	429,440	429,440
Key West Range Complex	79,008	79,008	395,040	395,040
Gulf of Mexico Range Complex	2,128	2,128	10,640	10,640
Inshore Waters (see Table 3.0.33)	20,400	20,400	102,000	102,000
Total	**238,652**	**238,652**	**1,193,260**	**1,193,260**
Flares				
Virginia Capes Range Complex	1,040	1,040	5,200	5,200
Navy Cherry Point Range Complex	22,348	22,348	111,740	111,740
Jacksonville Range Complex	38,048	38,048	190,240	190,240
Key West Range Complex	31,008	31,008	155,040	155,040
Gulf of Mexico Range Complex	1,840	1,840	9,200	9,200
Inshore Waters (see Table 3.0-33)	20,400	20,400	102,000	102,000
Total	**114,684**	**114,684**	**573,420**	**573,420**
Flare O-Rings				
Virginia Capes Range Complex	1,040	1,040	5,200	5,200
Navy Cherry Point Range Complex	22,348	22,348	111,740	111,740
Jacksonville Range Complex	38,048	38,048	190,240	190,240
Key West Range Complex	31,008	31,008	155,040	155,040
Gulf of Mexico Range Complex	1,840	1,840	9,200	9,200
Inshore Waters (see Table 3.0-33)	20,400	20,400	102,000	102,000
Total	**114,684**	**114,684**	**573,420**	**573,420**
Fiber Optic Canister				
Virginia Capes Range Complex	62	62	306	306
Navy Cherry Point Range Complex	1	1	5	5
Jacksonville Range Complex	2	2	6	6
Gulf of Mexico Range Complex	22	22	106	106
Total	**87**	**87**	**423**	**423**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Expendable Bathythermographs				
Northeast Range Complexes	142	142	708	708
Virginia Capes Range Complex	414	439	2,065	2,193
Navy Cherry Point Range Complex	108	113	535	563
Jacksonville Range Complex	1,353	1,391	6,402	6,953
Gulf of Mexico Range Complex	5	128	25	640
Other AFTT Areas	154	154	770	770
Total	**2,176**	**2,367**	**10,505**	**11,827**
Heavyweight Torpedo Accessories				
Northeast Range Complexes	24	24	120	120
Virginia Capes Range Complex	8	8	40	40
Jacksonville Range Complex	48	48	240	240
SINKEX	1	1	5	5
Total	**81**	**81**	**405**	**405**
Lightweight Torpedo Accessories				
Virginia Capes Range Complex	13	13	65	65
Jacksonville Range Complex	44	44	220	220
Total	**57**	**57**	**285**	**285**
Marine Markers				
Virginia Capes Range Complex	1,022	1,022	5,110	5,110
Navy Cherry Point Range Complex	332	332	1,660	1,660
Jacksonville Range Complex	1,060	1,060	5,300	5,300
Key West Range Complex	30	30	150	150
Gulf of Mexico Range Complex	53	53	265	265
Other AFTT Areas	24	24	120	120
Inshore Waters (see Table 3.0-33)	1,106	1,106	5,530	5,530
Total	**3,627**	**3,627**	**18,135**	**18,135**
Non-Explosive Buoy				
Virginia Capes Range Complex	24	34	114	170
Navy Cherry Point Range Complex	17	22	73	110
Jacksonville Range Complex	116	186	550	930
Gulf of Mexico Range Complex	0	16	0	80
Total	**157**	**258**	**737**	**1,290**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Non-Explosive Sonobuoy				
Northeast Range Complexes	2,882	2,882	14,410	14,410
Virginia Capes Range Complex	7,484	7,484	37,204	37,420
Navy Cherry Point Range Complex	2,542	2,542	12,332	12,710
Jacksonville Range Complex	27,237	27,237	134,673	136,185
Gulf of Mexico Range Complex	0	702	0	3,510
Other AFTT Areas	432	432	2,160	2,160
Total	**40,577**	**41,279**	**200,779**	**206,395**
Decelerators/Parachutes - Small				
Northeast Range Complexes	2,882	2,882	14,410	14,410
Virginia Capes Range Complex	7,497	7,497	37,244	37,460
Navy Cherry Point Range Complex	2,542	2,542	12,332	12,710
Jacksonville Range Complex	27,265	27,265	134,813	136,325
Gulf of Mexico Range Complex	0	702	0	3,510
Other AFTT Areas	432	432	2,160	2,160
Total	**40,618**	**41,320**	**200,959**	**206,575**
Decelerators/Parachutes - Medium				
Virginia Capes Range Complex	40	40	200	200
Navy Cherry Point Range Complex	48	48	240	240
Jacksonville Range Complex	48	48	240	240
Key West Range Complex	8	8	40	40
Total	**144**	**144**	**720**	**720**
Decelerators/Parachutes - Large				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	30	30	150	150
Gulf of Mexico Range Complex	1	1	5	5
Jacksonville Range Complex	1	1	5	5
Total	**33**	**33**	**165**	**165**
Decelerators/Parachutes – Extra Large				
Virginia Capes Range Complex	5	5	25	25
Total	**5**	**5**	**25**	**25**
Sabot-Kinetic Energy Round				
Virginia Capes Range Complex	32	32	160	160
Navy Cherry Point Range Complex	4	4	20	20
Jacksonville Range Complex	4	4	20	20
Gulf of Mexico Range Complex	4	4	20	20
Other AFTT Areas	4	4	20	20
Total	**48**	**48**	**240**	**240**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
JATO Bottles				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	35	35	175	175
Jacksonville Range Complex	1	1	5	5
Gulf of Mexico Range Complex	1	1	5	5
Total	**38**	**38**	**190**	**190**

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise; JATO = Jet Assisted Take-Off

Table 3.0-33: Number and Location of Other Military Materials Expended During Training Activities in Inshore Waters

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Marine Markers				
Narragansett, RI	64	64	320	320
James River and Tributaries	728	728	3,640	3,640
York River	20	20	100	100
Lower Chesapeake Bay	230	230	1,150	1,150
Port Canaveral, FL	64	64	320	320
Total	**1,106**	**1,106**	**5,530**	**5,530**
Flares				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**
Flare O-Ring				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**
Compression Pad or Plastic Piston				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**
Endcap – Chaff and Flare				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Acoustic Countermeasures				
Northeast Range Complexes	843	843	4,018	4,018
Virginia Capes Range Complex	1,163	1,163	5,814	5,814
Navy Cherry Point Range Complex	708	708	3,540	3,540
Jacksonville Range Complex	1,508	1,508	7,145	7,145
Gulf of Mexico Range Complex	697	697	3,484	3,484
NUWC Newport Testing Range	64	64	320	320
SFOMF	17	17	84	84
Total	**5,000**	**5,000**	**24,405**	**24,405**
Anchors (Other)				
Northeast Range Complexes	685	685	3,425	3,425
Virginia Capes Range Complex	343	343	1,713	1,713
Jacksonville Range Complex	20	20	100	100
Gulf of Mexico Range Complex	338	338	1,688	1,688
NUWC Newport Testing Range	70	70	350	350
SFOMF	654	654	3,270	3,270
Total	**2,110**	**2,110**	**10,546**	**10,546**
Anchors (Mine)				
Virginia Capes Range Complex	2	7	10	35
NSWC Panama City Testing Range	4	9	20	45
Total	**6**	**16**	**30**	**80**
Concrete Slugs				
Northeast Range Complexes	38	38	190	190
Gulf of Mexico Range Complex	38	38	190	190
Total	**76**	**76**	**380**	**380**
Compression Pad/Piston				
Virginia Capes Range Complex	20,195	20,195	100,975	100,975
Gulf of Mexico Range Complex	600	600	3,000	3,000
Total	**20,795**	**20,795**	**103,975**	**103,975**
Chaff – Air Cartridge				
Virginia Capes Range Complex	20,595	20,595	102,975	102,975
Jacksonville Range Complex	400	400	2,000	2,000
Gulf of Mexico Range Complex	1,200	1,200	6,000	6,000
Total	**22,195**	**22,195**	**110,975**	**110,975**

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Chaff – Ship Cartridge				
Northeast Range Complexes	144	144	720	720
Virginia Capes Range Complex	1,019	1,019	4,955	4,955
Navy Cherry Point Range Complex	144	144	720	720
Jacksonville Range Complex	480	480	2,400	2,400
Key West Range Complex	144	144	720	720
Gulf of Mexico Range Complex	144	144	720	720
Total	**2,075**	**2,075**	**10,235**	**10,235**
Canister-Miscellaneous				
Northeast Range Complexes	240	240	1,200	1,200
Virginia Capes Range Complex	240	240	1,200	1,200
Total	**480**	**480**	**2,400**	**2,400**
Endcaps – Chaff & Flare				
Virginia Capes Range Complex	40,790	40,790	203,950	203,950
Jacksonville Range Complex	400	400	2,000	2,000
Gulf of Mexico Range Complex	1,800	1,800	9,000	9,000
Total	**42,990**	**42,990**	**214,950**	**214,950**
Endcaps and Pistons (Non Chaff & Flare)				
NUWC Newport Testing Range	379	379	1,895	1,895
Total	**379**	**379**	**1,895**	**1,895**
Flares				
Virginia Capes Range Complex	20,195	20,195	100,975	100,975
Gulf of Mexico Range Complex	600	600	3,000	3,000
Total	**20,795**	**20,795**	**103,975**	**103,975**
Flare O-Rings				
Virginia Capes Range Complex	20,195	20,195	100,975	100,975
Gulf of Mexico Range Complex	600	600	3,000	3,000
Total	**20,795**	**20,795**	**103,975**	**103,975**
Fiber Optic Canister				
Virginia Capes Range Complex	250	255	1,090	1,275
Jacksonville Range Complex	50	50	250	250
Gulf of Mexico Range Complex	100	100	500	500
NSWC Panama City Testing Range	328	333	1,584	1,665
Total	**728**	**738**	**3,424**	**3,690**

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Expendable Bathythermographs				
Northeast Range Complexes	21,104	21,104	105,516	105,516
Virginia Capes Range Complex	9,740	9,740	48,697	48,697
Navy Cherry Point Range Complex	277	277	1,385	1,385
Jacksonville Range Complex	561	561	2,775	2,805
Key West Range Complex	10	10	50	50
Gulf of Mexico Range Complex	9,813	9,813	49,063	49,063
SFOMF	4	4	20	20
Total	**41,509**	**41,509**	**207,506**	**207,536**
Heavyweight Torpedo Accessories				
Northeast Range Complexes	98	98	421	469
Virginia Capes Range Complex	128	128	591	639
Navy Cherry Point Range Complex	42	42	210	210
Jacksonville Range Complex	134	134	579	627
Key West Range Complex	2	2	10	10
Gulf of Mexico Range Complex	84	84	371	419
NUWC Newport Testing Range	20	20	100	100
SFOMF	6	6	29	29
Total	**514**	**514**	**2,311**	**2,503**
Lightweight Torpedo Accessories				
Northeast Range Complexes	54	54	267	267
Virginia Capes Range Complex	225	225	867	1,110
Navy Cherry Point Range Complex	50	50	247	247
Jacksonville Range Complex	213	213	981	981
Key West Range Complex	2	2	7	7
Gulf of Mexico Range Complex	54	54	267	267
NUWC Newport Testing Range	20	20	100	100
NSWC Panama City Testing Range	192	192	960	960
Total	**810**	**810**	**3,696**	**3,939**
Non-Explosive Sonobuoy				
Northeast Range Complexes	3,596	3,715	15,911	18,375
Virginia Capes Range Complex	5,505	5,548	24,329	27,740
Navy Cherry Point Range Complex	2,144	2,187	10,606	10,935
Jacksonville Range Complex	5,847	6,062	29,845	29,910
Key West Range Complex	3,007	3,007	14,807	15,036
Gulf of Mexico Range Complex	2,027	2,027	9,550	10,135
NUWC Newport Testing Range	1,200	1,200	6,000	6,000
SFOMF	32	32	160	160

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	***Alternative 2***	***Alternative 1***	***Alternative 2***
NSWC Panama City Testing Range	192	192	960	960
Total	**23,550**	**23,970**	**112,168**	**119,251**
Decelerators/Parachutes – Small				
Northeast Range Complexes	3,637	3,756	16,116	18,580
Virginia Capes Range Complex	5,711	5,754	25,108	28,762
Navy Cherry Point Range Complex	2,185	2,228	10,811	11,140
Jacksonville Range Complex	6,037	6,252	28,718	30,852
Key West Range Complex	3,008	3,008	14,812	15,310
Gulf of Mexico Range Complex	2,068	2,068	9,755	10,340
NUWC Newport Testing Range	1,200	1,200	6,000	6,000
SFOMF	32	32	160	160
NSWC Panama City Testing Range	192	192	960	960
Total	**24,070**	**24,490**	**112,440**	**122,104**
Decelerators/Parachutes - Large				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	14	14	70	70
Jacksonville Range Complex	1	1	5	5
Gulf of Mexico Range Complex	1	1	5	5
Total	**17**	**17**	**85**	**85**
Sabot – Kinetic Energy Round				
Northeast Range Complexes	33,503	33,503	167,054	167,054
Virginia Capes Range Complex	33,503	33,503	167,054	167,054
Navy Cherry Point Range Complex	33,503	33,503	167,054	167,054
Jacksonville Range Complex	33,503	33,503	167,054	167,054
Key West Range Complex	33,503	33,503	167,054	167,054
Gulf of Mexico Range Complex	33,503	33,503	167,054	167,054
NUWC Newport Testing Range	4	4	4	4
SFOMF	4	4	4	4
NSWC Panama City Testing Range	4	4	4	4
Total	**201,030**	**201,030**	**1,002,336**	**1,002,336**
JATO Bottles				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	14	14	70	70
Jacksonville Range Complex	1	1	5	5
Gulf of Mexico Range Complex	1	1	5	5
Total	**17**	**17**	**85**	**85**

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise; JATO = Jet Assisted Take-Off

3.0.3.3.4.3 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 and do not pose a threat to highly mobile organisms when in place, however during the deployment process, they may pose a physical disturbance or strike risk. The effect of devices on the bottom will be discussed as an alteration of the bottom substrate and associated living resources (e.g., invertebrates and vegetation) and cultural resources.

Table 3.0-35 and Table 3.0-36 show the number and location of proposed activities that include the use of seafloor devices.

Table 3.0-35: Number and Location of Activities Including Seafloor Devices

	Maximum Annual # of Activities		*5-Year # of Activities*	
Activity Area	***Alternative 1***	***Alternative 2***	***Alternative 1***	***Alternative 2***
Training				
Virginia Capes Range Complex	3,176	3,176	15,978	15,978
Navy Cherry Point Range Complex	662	662	3,260	3,260
Jacksonville Range Complex	665	665	3,321	3,321
Key West Range Complex	23	23	115	115
Gulf of Mexico Range Complex	383	383	1,911	1,911
NSWC Panama City Testing Range	244	244	1,220	1,220
Inshore Waters (see Table 3.0-36)	523	523	2,635	2,635
Total	**5,676**	**5,676**	**28,440**	**28,440**
Testing				
Northeast Range Complexes	11	11	55	55
Virginia Capes Range Complex	159	169	665	843
Navy Cherry Point Range Complex	10	10	50	50
Jacksonville Range Complex	33	33	149	149
Key West Range Complex	1	1	3	3
Gulf of Mexico Range Complex	50	50	247	247
NUWC Newport Testing Range	322	322	1,608	1,608
SFOMF	100	100	498	498
NSWC Panama City Testing Range	344	354	1,600	1,742
Total	**1,030**	**1,050**	**4,875**	**5,195**

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-36: Number and Location of Activities in Inshore Waters Including Seafloor Devices

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	1	1	3	3
Earle, NJ	1	1	3	3
Delaware Bay, DE	1	1	3	3
Hampton Roads, VA	2	2	6	6
Lower Chesapeake Bay, VA	308	308	1,540	1,540
James River & Tributaries, VA	75	75	425	425
York River, VA	19	19	95	95
Morehead City, NC	1	1	3	3
Wilmington, NC	1	1	3	3
Savannah, GA	1	1	3	3
Kings Bay, GA	23	23	113	113
Mayport, FL	1	1	3	3
Port Canaveral, FL	1	1	3	3
Truman Harbor, FL	42	42	210	210
Demolition Key	42	42	210	210
Tampa, FL	1	1	3	3
Beaumont, TX	2	2	6	6
Corpus Christi, TX	1	1	3	3
Total	**523**	**523**	**2,635**	**2,635**

3.0.3.3.4.4 Aircraft

Aircraft involved in Navy training and testing activities are separated into three categories: (1) fixed-wing aircraft, (2) rotary-wing aircraft, (3) tiltrotor aircraft, and (4) unmanned aerial systems. Fixed-wing aircraft include, but are not limited to, planes such as F-35, P-8, F/A-18, and E/A-18G. Rotary-wing aircraft are also referred to as helicopters (e.g., MH-60), and tiltrotor aircraft include the MV-22. Unmanned aerial systems include a variety of platforms, including but not limited to, the Small Tactical Unmanned Aerial System – Tier II, Triton unmanned aerial system, Fire Scout Vertical Take-off and Landing Unmanned Aerial System, and the MQ-25 Stingray Carrier Based Unmanned Aerial System. Aircraft strikes are only applicable to birds and bats. Table 3.0-37 and Table 3.0-38 show the number and location of proposed activities that include the use of aircraft.

Table 3.0-37: Number and Location of Activities Including Aircraft

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Northeast Range Complexes	92	92	460	460
Virginia Capes Range Complex	22,111	22,111	110,541	110,553
Navy Cherry Point Range Complex	36,031	36,031	180,134	180,155
Jacksonville Range Complex	38,101	38,101	190,470	190,503
Key West Range Complex	26,346	26,346	131,730	131,730
Gulf of Mexico Range Complex	1,088	1,099	5,438	5,493
NSWC Panama City Testing Range	244	244	1,220	1,220
Other AFTT Areas	48	48	240	240
Inshore Waters (see Table 3.0-38)	3,634	3,634	15,520	15,520
Total	**127,695**	**127,706**	**635,753**	**635,874**
Testing				
Northeast Range Complexes	756	759	3,492	3,792
Virginia Capes Range Complex	4,595	4,601	21,807	22,862
Navy Cherry Point Range Complex	639	640	3,189	3,197
Jacksonville Range Complex	921	926	4,318	4,563
Key West Range Complex	253	253	1,132	1,258
Gulf of Mexico Range Complex	192	192	858	925
NUWC Newport Testing Range	49	49	239	239
SFOMF	35	35	170	170
NSWC Panama City Testing Range	229	234	1,045	1,162
Inshore Waters (see Table 3.0-38)	4	4	4	4
Total	**7,673**	**7,693**	**36,254**	**38,172**

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-38: Number and Location of Activities in Inshore Waters Including Aircraft

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	1	1	3	3
Earle, NJ	1	1	3	3
Delaware Bay, DE	1	1	3	3
Hampton Roads, VA	2	2	6	6
Lower Chesapeake Bay	1,624	1,624	5,500	5,500
James River & Tributaries	1,282	1,282	6,410	6,410
York River	4	4	20	20

Table 3.0-38: Number and Location of Activities in Inshore Waters Including Aircraft (continued)

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Morehead City, NC	1	1	3	3
Wilmington, NC	1	1	3	3
Savannah, GA	1	1	3	3
Kings Bay, GA	481	481	2,403	2,403
Mayport, FL	36	36	178	178
St. Johns River, FL	144	144	720	720
Port Canaveral, FL	1	1	3	3
Tampa, FL	1	1	3	3
St. Andrew Bay, FL	50	50	250	250
Beaumont, TX	2	2	6	6
Corpus Christi, TX	1	1	3	3
Total	**3,634**	**3,634**	**15,520**	**15,520**
Testing				
Little Creek, VA	2	2	2	2
Norfolk, VA	2	2	2	2
Total	**4**	**4**	**4**	**4**

3.0.3.3.5 Entanglement Stressors

This section describes the entanglement stressors introduced into the water through naval training and testing, the relative magnitude and location of these activities, and provides the basis for analysis of potential impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). To assess the entanglement risk of materials expended during training and testing, the Navy examined the characteristics of these items (e.g., size and rigidity) for their potential to entangle marine animals. For a constituent of military expended materials to entangle a marine animal the item must be flexible enough to wrap around the animal or appendages, or trapped in the jaw, baleen, etc. This analysis includes the potential impacts from three types of military expended materials: (1) wires and cables, (2) decelerators/parachutes, and (3) biodegradable polymer. The Navy deploys equipment designed for military purposes and strives to reduce the risk of accidental entanglement posed by any item it releases into the sea. Arresting gear cables are not an entanglement concern due to their heavy weight and thickness. These cables weigh approximately 450 lb., reach 110 ft. in length, and are several inches thick. Therefore, they do not loop and are not able to wrap around an animal or appendage and will not be discussed further in this document.

3.0.3.3.5.1 Wires and Cables

Fiber Optic Cables

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 (μm) (0.008 millimeter [mm]) silica core and acylate coating, and looks and feels like thin monofilament fishing line. Other characteristics of tactical fiber are a 242-µm (0.24 mm) diameter, 12-lb. tensile strength, and 3.4-mm bend radius (Corning Incorporated, 2005; Raytheon Company, 2015). 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 mm), or exceeds its tensile strength (12 lb.). 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 cm/second (Raytheon Company, 2015) where it would be susceptible to abrasion and burial by sedimentation.

Guidance Wires

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. Finally, the guidance wire is 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 lb. and can be broken by hand (Swope & McDonald, 2013), contrasting with the rope or lines associated with commercial fishing towed gear (trawls), stationary gear (traps), or entanglement gear (gillnets) that use lines with substantially higher (up to 500–2,000 lb.) breaking strength as their “weak links.” However, it has a somewhat higher breaking strength than the monofilament used in the body of most commercial gillnets (typically 31 lb. 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 & McDonald, 2013). Torpedo guidance wire sinks at a rate of 0.24 m per second (Swope & McDonald, 2013).

Sonobuoy Wire

Sonobuoys consist of a surface antenna and float unit and a subsurface hydrophone assembly unit. The two units are attached through a thin-gauge, dual-conductor, and hard-draw copper strand wire, which is then wrapped by a hollow rubber tubing or bungee in a spiral configuration. The tensile breaking strength of the wire and rubber tubing is no more than 40 lb. 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 type of sonobuoy, but pose no entanglement risk. Each sonobuoy has a saltwater-activated polyurethane float that inflates when the sonobuoy is submerged, keeping 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.

Table 3.0-39 and Table 3.0-40 show the number and location of wires and cables expended during proposed training and testing activities.

Table 3.0-39: Number and Location of Wires and Cables Expended During Training Activities

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Fiber Optic Cables				
Virginia Capes Range Complex	62	62	306	306
Navy Cherry Point Range Complex	9	9	45	45
Jacksonville Range Complex	2	2	6	6
Gulf of Mexico Range Complex	22	22	106	106
Total	**95**	**95**	**463**	**463**
Guidance Wires				
Northeast Range Complexes	24	24	120	120
Virginia Capes Range Complex	8	8	40	40
Jacksonville Range Complex	48	48	240	240
SINKEX Area	1	1	5	5
Total	**81**	**81**	**405**	**405**
Sonobuoy Wires				
Northeast Range Complexes	2,882	2,882	14,410	14,410
Virginia Capes Range Complex	7,484	7,484	37,204	37,420
Navy Cherry Point Range Complex	2,542	2,542	12,332	12,710
Jacksonville Range Complex	27,237	27,237	134,673	136,185
Gulf of Mexico Range Complex	0	702	0	3,510
Other AFTT Areas	432	432	2,160	2,160
Total	**40,577**	**41,279**	**200,779**	**206,395**
Expendable Bathythermograph Wires				
Northeast Range Complexes	142	142	708	708
Virginia Capes Range Complex	414	439	2,065	2,193
Navy Cherry Point Range Complex	108	113	535	563
Jacksonville Range Complex	1,353	1,391	6,402	6,953
Gulf of Mexico Range Complex	5	128	25	640
Other AFTT Areas	154	154	770	770
Total	**2,176**	**2,367**	**10,505**	**11,827**

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

Table 3.0-40: Number and Location of Wires and Cables Expended During Testing Activities

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Fiber Optic Cables				
Virginia Capes Range Complex	250	255	1,090	1,275
Jacksonville Range Complex	50	50	250	250
Gulf of Mexico Range Complex	100	100	500	500
NSWC Panama City Testing Range	328	333	1,584	1,665
Total	**728**	**738**	**3,424**	**3,690**
Guidance Wires				
Northeast Range Complexes	98	98	421	469
Virginia Capes Range Complex	128	128	591	639
Navy Cherry Point Range Complex	42	42	210	210
Jacksonville Range Complex	134	134	579	627
Key West Range Complex	2	2	10	10
Gulf of Mexico Range Complex	84	84	371	419
NUWC Newport Testing Range	20	20	100	100
SFOMF	6	6	29	29
Total	**514**	**514**	**2,311**	**2,503**
Sonobuoy Wires				
Northeast Range Complexes	3,596	3,715	15,911	18,375
Virginia Capes Range Complex	5,505	5,548	24,329	27,740
Navy Cherry Point Range Complex	2,144	2,187	10,606	10,935
Jacksonville Range Complex	5,847	6,062	27,845	29,910
Key West Range Complex	3,007	3,007	14,807	15,305
Gulf of Mexico Range Complex	2,027	2,027	9,550	10,135
NUWC Newport Testing Range	1,200	1,200	6,000	6,000
SFOMF	32	32	160	160
NSWC Panama City Testing Range	192	192	960	960
Total	**23,550**	**23,970**	**110,168**	**119,520**
Expendable Bathythermograph Wires				
Northeast Range Complexes	21,104	21,104	105,516	105,516
Virginia Capes Range Complex	9,740	9,740	48,667	48,697
Navy Cherry Point Range Complex	277	277	1,385	1,385
Jacksonville Range Complex	561	561	2,775	2,805
Key West Range Complex	10	10	50	50
Gulf of Mexico Range Complex	9,813	9,813	49,063	49,063
SFOMF	4	4	20	20
Total	**41,509**	**41,509**	**207,476**	**207,536**

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

3.0.3.3.5.2 Decelerators/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 3.0-41). 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.) cross shape decelerators/parachutes associated with sonobuoys (Figure 3.0-13). Illumination flares use large 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 attached to 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 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor, where the fabric becomes flattened (Environmental Sciences Group, 2005). Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Table 3.0-41: Size Categories for Decelerators/Parachutes Expended During Training and Testing Activities

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

Figure 3.0-13: Sonobuoy Launch Depicting the Relative Size of a Parachute

Aerial targets (drones) use large (between 30 and 50 ft. in diameter) and extra-large (80 ft. in diameter) decelerators/parachutes (Figure 3.0-14). Large and extra-large decelerators/parachutes are also made of cloth and nylon, with suspension lines of varying lengths (large: 40–70 ft. in length [with up to 28 lines per decelerator/parachute]; 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.

Figure 3.0-14: Aerial Target (Drone) with Parachute Deployed

Table 3.0-32 and Table 3.0-34 show the number and location of decelerator/parachutes expended during proposed training and testing activities.

3.0.3.3.5.3 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 the propellers of in-water vessels. Biodegradable polymers degrade to smaller compounds as a result of microorganisms and enzymes. The biodegradable polymers that the Navy uses are designed to temporarily interact with the propeller(s) of a target craft rendering it ineffective. 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. This will break down further and dissolve into the water column within weeks to a few months. Degradation and dispersal timelines 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.

Biodegradable polymers will be used only during proposed testing activities, not during training activities. Table 3.0-42 shows the number and location of proposed testing activities that use biodegradable polymer.

Table 3.0-42: Number and Location of Activities Including Biodegradable Polymers During Testing

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Biodegradable Polymer				
Virginia Capes Range Complex	30	30	150	150
Jacksonville Range Complex	30	30	150	150
Key West Range Complex	30	30	150	150
Gulf of Mexico Range Complex	30	30	150	150
NUWC Newport Testing Range	30	30	150	150
Total	**150**	**150**	**750**	**750**

Notes: NUWC = Naval Undersea Warfare Center

3.0.3.3.6 Ingestion Stressors

This section describes the ingestion stressors introduced into the water through naval training and testing and the relative magnitude and location of these activities in order to provide the basis for analysis of potential impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). To assess the ingestion risk of materials expended during training and testing, the Navy examined the characteristics of these items (such as buoyancy and size) for their potential to be ingested by marine animals in the Study Area. The Navy expends the following types of materials that could become ingestion stressors during training and testing in the Study Area: 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]).

3.0.3.3.6.1 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. This would vary depending on the resource and will be discussed in more detail within each resource section. 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. Table 3.0-24, Table 3.0-25, and Table 3.0-26 show the number and location of non-explosive practice munitions used during proposed training and testing activities.

3.0.3.3.6.2 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, anti-torpedo countermeasures, mines, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munition type; typical sizes of fragments are unknown. These solid metal materials would quickly sink through the water column and settle to the seafloor. Table 3.0-27 and Table 3.0-28 show the number and location of explosives used during training and testing activities that may result in fragments.

3.0.3.3.6.3 Military Expended Materials Other Than Munitions

Several different types of materials other than munitions are expended at sea during training and testing activities.

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. Only targets that may result in smaller fragments are included in the analyses of ingestion potential.

There are additional types of targets discussed previously, but only surface targets, air targets, ship hulks, and mine shapes would be expected to result in fragments when high-explosive munitions are used. Table 3.0-43 and Table 3.0-44 show the number and location of targets used during proposed training and testing activities that may result in fragments.

Table 3.0-43: Number and Location of Targets Expended During Training Activities That May Result in Fragments

Activity Area	*Maximum Annual # of Targets*		*5-Year # of Targets*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Air Targets				
Northeast Range Complexes	2	2	12	12
Virginia Capes Range Complex	99	99	497	497
Navy Cherry Point Range Complex	80	80	398	398
Jacksonville Range Complex	68	68	339	339
Key West Range Complex	11	11	55	55

Table 3.0-43: Number and Location of Targets Expended During Training Activities That May Result in Fragments (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Gulf of Mexico Range Complex	2	2	12	12
Total	**262**	**262**	**1,313**	**1,313**
Surface Targets				
Northeast Range Complexes	20	20	100	100
Virginia Capes Range Complex	4,582	4,582	22,908	22,908
Navy Cherry Point Range Complex	1,321	1,321	6,604	6,604
Jacksonville Range Complex	3,091	3,091	15,453	15,453
Gulf of Mexico Range Complex	336	336	1,682	1,682
Other AFTT Areas	200	200	980	980
Total	**9,550**	**9,550**	**47,727**	**47,727**
Mine Shapes				
Virginia Capes Range Complex	221	221	1,105	1,105
Navy Cherry Point Range Complex	78	78	390	390
Jacksonville Range Complex	78	78	390	390
Key West Range Complex	2	2	8	8
Gulf of Mexico Range Complex	93	93	466	466
Total	**472**	**472**	**2,359**	**2,359**

Notes: AFTT = Atlantic Fleet Training and Testing

Table 3.0-44: Number and Location of Targets Expended During Testing Activities That May Result in Fragments

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Air Targets				
Northeast Range Complexes	14	14	69	69
Virginia Capes Range Complex	583	583	2,916	2,916
Navy Cherry Point Range Complex	6	6	29	29
Jacksonville Range Complex	168	168	842	842
Key West Range Complex	13	13	63	63
Gulf of Mexico Range Complex	25	25	125	125
Total	**809**	**809**	**4,044**	**4,044**
Surface Targets				
Northeast Range Complexes	173	173	863	863
Virginia Capes Range Complex	984	984	4,778	4,924
Navy Cherry Point Range Complex	172	172	858	858
Jacksonville Range Complex	545	545	2,673	2,824
Key West Range Complex	180	180	900	900

Table 3.0-44: Number and Location of Targets Expended During Testing Activities That May Result in Fragments (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Gulf of Mexico Range Complex	250	259	1,222	1,252
NUWC Newport Testing Range	934	934	4,671	4,671
SFOMF	56	56	282	282
Total	**3,294**	**3,303**	**16,247**	**16,574**
Mine Shapes				
Virginia Capes Range Complex	127	127	536	636
Jacksonville Range Complex	122	122	610	610
Gulf of Mexico Range Complex	232	232	1,158	1,158
SFOMF	40	40	200	200
NSWC Panama City Testing Range	370	370	1,815	1,850
Total	**891**	**891**	**4,319**	**4,454**

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

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 masks the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force, 1997). Chaff is released or dispensed in cartridges or projectiles 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; U.S. Air Force, 1997). Doppler radar has tracked chaff plumes containing approximately 900 g of chaff drifting 200 mi. from the point of release, with the plume covering greater than 400 $mi.^3$ (Arfsten et al., 2002).

The chaff concentrations that marine animals could be exposed to following the release 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. Chaff concentrations in benthic habitats following the release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the dilution capacity of the ocean.

Several literature reviews and controlled experiments indicate that chaff poses little risk to organisms, except at concentrations substantially higher than those that could reasonably occur from military training (Arfsten et al., 2002; U.S. Air Force, 1997; U.S. Department of the Navy, 1999). Nonetheless, some marine animal species within the Study Area could be exposed to chaff through direct body contact, inhalation, and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to occur. Based on the dispersion characteristics of chaff, it is likely that marine animals would occasionally come in direct contact with chaff fibers while either at the water's surface or while submerged, but such contact would be inconsequential. Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force, 1997) and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force, 1997). The potential exists for marine animals to inhale chaff fibers if they are at the surface while chaff is airborne. Arfsten et al. (2002), (U.S. Department of the Navy, 1999), and U.S. Air Force (1997) reviewed the potential impacts of chaff inhalation on humans, livestock, and other animals and concluded that the fibers are too large to be inhaled into the lungs. The fibers were predicted to be deposited in the nose, mouth, or trachea and either swallowed or expelled.

In laboratory studies conducted by the University of Delaware (U.S. Department of the Navy, 1999), blue crabs and killifish were fed a food-chaff mixture daily for several weeks, and no significant mortality was observed at the highest exposure treatment. Similar results were found when chaff was added directly to exposure chambers containing filter-feeding menhaden. Histological examination indicated no damage from chaff exposures. A study on cow calves that were fed chaff found no evidence of digestive disturbance or other clinical symptoms (U.S. Air Force, 1997).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, where they would persist for long periods and could be ingested by marine animals. Chaff end caps and pistons sink in saltwater (Spargo, 2007).

Table 3.0-32 and Table 3.0-34 show the number and location of chaff cartridges, chaff canisters, and chaff components used during training and testing activities.

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 in. in diameter and 5.8 in. 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 g depending on flare type). The flare pads and pistons float in sea water.

An extensive literature review and controlled experiments conducted by the U.S. Air Force revealed that self-protection flare use poses little risk to the environment or animals (U.S. Air Force, 1997).

Table 3.0-32, Table 3.0-33, and Table 3.0-34 show the number and location of flares and flare components expended during training and testing activities.

Decelerators/Parachutes

Decelerators/parachutes are expended with the use of sonobuoys, lightweight torpedoes, and illumination flares. Only the small-size decelerators/parachutes expended with sonobuoys and lightweight torpedoes pose an ingestion risk to marine life. See Section 3.0.3.3.5.2 (Decelerators/Parachutes) above for a complete description.

Table 3.0-32 and Table 3.0-34 show the number and location of small-size decelerators/parachutes expended during proposed training and testing activities.

3.0.3.4 Resource-Specific Impacts Analysis for Individual Stressors

The direct and indirect impacts of each stressor are analyzed in each resource section for which there may be an impact. Quantitative methods were used to the extent possible, but data limitations required the use of qualitative methods for most stressor/resource interactions. Resource-specific methods are described in sections of Chapter 3 (Affected Environment and Environmental Consequences), where applicable. While specific methods used to analyze the impacts of individual stressors varied by resource, the following generalized approach was used for all stressor/resource interactions:

- The frequency, duration, and spatial extent of exposure to stressors were analyzed for each resource. The frequency of exposure to stressors or frequency of a proposed activity was characterized as intermittent or continuous, and was quantified in terms of number per unit of time when possible. Duration of exposure was expressed as short or long term and was quantified in units of time (e.g., seconds, minutes, and hours) when possible. The spatial extent of exposure was generally characterized as widespread or localized, and the stressor footprint or area (e.g., square feet, square nautical miles) was quantified when possible.
- An analysis was conducted to determine whether and how resources are likely to respond to stressor exposure or be altered by stressor exposure based upon available scientific knowledge. This step included reviewing available scientific literature and empirical data. For many stressor/resource interactions, a range of likely responses or endpoints was identified. For example, exposure of an organism to sound produced by an underwater explosion could result in no response, a physiological response such as increased heart rate, a behavioral response such as being startled, or injury.
- The information obtained was used to analyze the likely impacts of individual stressors on a resource and to characterize the type, duration, and intensity (severity) of impacts. The type of impact was generally defined as beneficial or adverse and was further defined as a specific endpoint (e.g., change in behavior, mortality, change in concentration, loss of habitat, loss of fishing time). When possible, the endpoint was quantified. The duration of an impact was generally characterized as short term (e.g., minutes, days, weeks, months, depending on the resource), long-term (e.g., months, years, decades, depending on the resource), or permanent. The intensity of an impact was then determined. For biological resources, the analysis started with individual organisms and their habitats, and then addressed populations, species, communities, and representative ecosystem characteristics, as appropriate.

3.0.3.5 Resource-Specific Impacts Analysis for Multiple Stressors

The stressors associated with the proposed training and testing activities could affect the environment individually or in combination. The impacts of multiple stressors may be different when considered collectively rather than individually. Therefore, following the resource-specific impacts analysis for individual stressors, the combined impacts of all stressors were analyzed for that resource. This step determines the overall impacts of the alternatives on each resource, and it considers the potential for impacts that are additive (where the combined impacts on the resource are equal to the sum of the individual impacts), synergistic (where impacts combine in such a way as to amplify the effect on the resource), and antagonistic (where impacts will cancel each other out or reduce a portion of the effect on the resource). This analysis helps inform the cumulative impacts analysis and make overall impact conclusions for each resource.

Evaluating the combined impacts of multiple stressors can be complex, especially when the impacts associated with a stressor are hard to measure. Therefore, some general assumptions were used to help determine the potential for individual stressors to contribute to combined impacts. For this analysis, combined impacts were considered more likely to occur in the following situations:

- Stressors co-occur in time and space, causing a resource to be simultaneously affected by more than one stressor.
- A resource is repeatedly affected by multiple stressors or is re-exposed before fully recovering from a previous exposure.
- The impacts of individual stressors are permanent or long-term (years or decades) versus short term (minutes, days, or months).
- The intensity of the impacts from individual stressors contributes to a combined overall adverse impact.

The resource-specific impacts analysis for multiple stressors included the following steps:

- Information obtained from the analysis of individual stressors was used to develop a conceptual model to predict the combined impacts of all stressors on each resource. This conceptual model incorporated factors such as the co-occurrence of stressors in space and time; the impacts or assessment endpoints of individual stressors (e.g., mortality, injury, changes in animal behavior or physiology, habitat alteration, or changes in human use); and the duration and intensity of the impacts of individual stressors.
- To the extent possible, additive impacts on a given resource were considered by summing the impacts of individual stressors. This summation was only possible for stressors with identical and quantifiable assessment endpoints. For example, if one stressor disturbed 0.25 square nautical miles (NM^2) of benthic habitat, a second stressor disturbed 0.5 NM^2, and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 NM^2. For stressors with identical but not quantifiable assessment endpoints, available scientific knowledge, best professional judgment, and the general assumptions outlined above were used to evaluate potential additive impacts.
- For stressors with differing impacts and assessment endpoints, the potential for additive, synergistic, and antagonistic effects were evaluated based on available scientific knowledge, professional judgment, and the general assumptions outlined above.

A cumulative impact is the impact on the environment that results when the incremental impact of an action is added to other past, present, and reasonably foreseeable future actions. The cumulative impacts analysis (Chapter 4, Cumulative Impacts) considers other actions regardless of what agency (federal or nonfederal) or person undertakes the actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 Code of Federal Regulations part 1508.7). The goal of the analysis is to provide the decision makers with information relevant to reasonably foresee potentially significant impacts. See Chapter 4 (Cumulative Impacts) for the specific approach used for determining cumulative impacts.

3.0.3.6 Biological Resource Methods

The analysis of impacts on biological resources focused on the likelihood of encountering the stressor, the primary stimulus, response, and recovery of individual organisms. Where appropriate, the potential of a biological resource to overlap with a stressor was analyzed with consideration given to the specific geographic area (large marine ecosystems, open ocean areas, range complexes, OPAREAs, and other training and testing areas) in which the overlap could occur. Additionally, the differential impacts of training versus testing activities that introduce stressors to the resource were considered.

For each of the non-biological resources considered in this EIS/OEIS, the methods are unique to each specific resource and are therefore described in each resource section. For Air Quality see Section 3.1.1.3 (Approach to Analysis), for Sediments and Water Quality see Section 3.2.1.2 (Methods), for Cultural Resources see Section 3.10.1.3 (Methods), for Socioeconomics see Section 3.11.1 (Introduction and Methods), and for Public Health and Safety see the Methods discussion under Section 3.12.1 (Introduction).

3.0.3.6.1 Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities

This conceptual framework describes the potential effects from exposure to acoustic and explosive activities and the accompanying short-term costs to the animal (e.g., expended energy or missed feeding opportunity). It then outlines the conditions that may lead to long-term consequences for the individual if the animal cannot fully recover from the short-term costs and how these in turn may affect the population. Within each biological resource section (e.g., marine mammals, birds and bats, and fishes) the detailed methods to predict effects on specific taxa are derived from this conceptual framework.

An animal is considered "exposed" to a sound if the received sound level at the animal's location is above the background ambient noise level within a similar frequency band. A variety of effects may result from exposure to acoustic and explosive activities.

The categories of potential effects are:

- ***Injury** and other non-auditory injury – Injury to organs or tissues of an animal.*
- ***Hearing loss** – A noise-induced decrease in hearing sensitivity which can be either temporary or permanent and may be limited to a narrow frequency range of hearing.*
- ***Masking** – When the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise).*
- ***Physiological stress** – An adaptive process that helps an animal cope with changing conditions; although, too much stress can result in physiological problems.*
- ***Behavioral response** – A reaction ranging from very minor and brief changes in attentional focus, changes in biologically important behaviors, and avoidance of a sound source or area, to aggression or prolonged flight.*

Figure 3.0-15 is a flowchart that diagrams the process used to evaluate the potential effects to marine animals exposed to sound-producing activities. The shape and color of each box on the flowchart represent either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles). Each box is labeled for reference throughout the following sections. For simplicity, sound is used here to include not only sound waves but also blast waves generated from explosive sources. Box A1, the Sound-Producing Activity, is the source of this stimuli and therefore the starting point in the analysis.

The first step in predicting whether an activity is capable of affecting a marine animal is to define the stimuli experienced by the animal. The stimuli include the overall level of activity, the surrounding acoustical environment, and characteristics of the sound when it reaches the animal.

Sounds emitted from a sound-producing activity (Box A1) travel through the environment to create a spatially variable sound field. The received sound at the animal (Box A2) determines the range of possible effects. The received sound can be evaluated in several ways, including number of times the sound is experienced (repetitive exposures), total received energy, or highest sound pressure level experienced. Sounds that are higher than the ambient noise level and within an animal's hearing sensitivity range (Box A3) have the potential to cause effects. There can be any number of individual sound sources in a given activity, each with its own unique characteristics. For example, a Navy training exercise may involve several ships and aircraft using several types of sonar. Environmental factors such as temperature and bottom type impact how sound spreads and attenuates through the environment. Additionally, independent of the sounds, the overall level of activity and the number and movement of sound sources are important to help predict the probable reactions.

The magnitude of the responses is based on the characteristics of the acoustic stimuli and the characteristics of the animal (species, susceptibility, life history stage, size, and past experiences). Very high exposure levels close to explosives have the potential to cause injury. High-level, long-duration, or repetitive exposures may potentially cause some hearing loss. All perceived sounds may lead to behavioral responses, physiological stress, and masking. Many sounds, including sounds that are not detectable by the animal, could have no effect (Box A4).

3.0.3.6.1.1 Injury

Injury (Box B1) refers to the direct injury of tissues and organs by shock or pressure waves impinging upon or traveling through an animal's body. Marine animals are well adapted to large, but relatively slow, hydrostatic pressures changes that occur with changing depth. However, injury may result from exposure to rapid pressure changes, such that the tissues do not have time to adequately adjust.

Therefore, injury is normally limited to relatively close ranges from explosions. Injury can be mild and fully recoverable or, in some cases, lead to mortality.

Injury includes both auditory and non-auditory injury. Auditory injury is the direct mechanical injury to hearing-related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and injury to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory injury differs from auditory fatigue in that the latter involves the overstimulation of the auditory system at levels below those capable of causing direct mechanical damage. Auditory injury is always injurious but can be temporary. One of the most common consequences of auditory injury is hearing loss.

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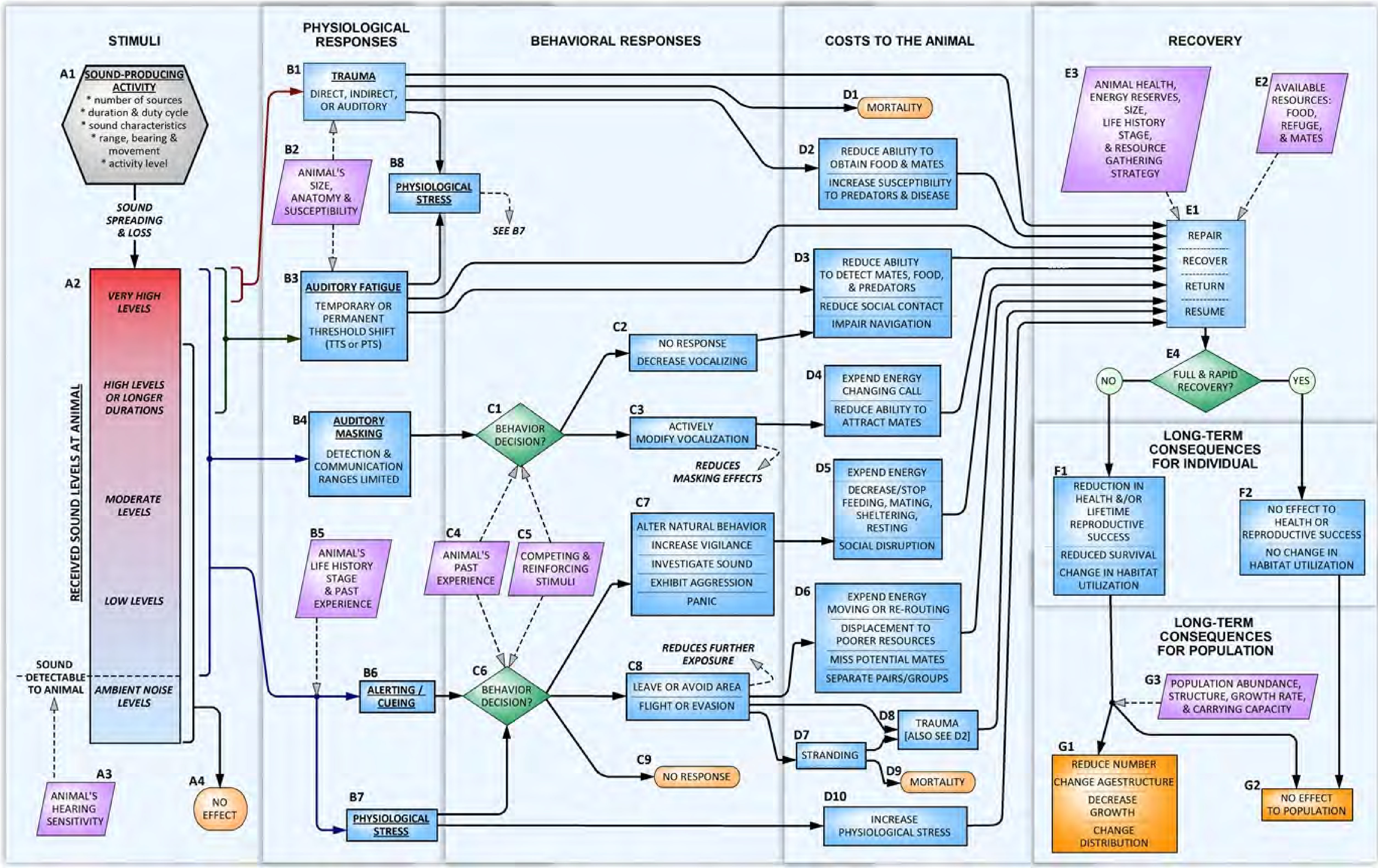

Figure 3.0-15: Flow Chart of the Evaluation Process of Sound-Producing Activities

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Non-auditory injury can include hemorrhaging of small blood vessels and the rupture of gas-containing tissues such as the lung, swim bladder, or gastrointestinal tract. After the ear (or other sound-sensing organs), these are usually the organs and tissues most sensitive to explosive injury. An animal's size and anatomy are important in determining its susceptibility to non-auditory injury (Box B2). Larger size indicates more tissue to protect vital organs. Therefore, larger animals should be less susceptible to injury than smaller animals. In some cases, acoustic resonance of a structure may enhance the vibrations resulting from noise exposure and result in an increased susceptibility to injury. The size, geometry, and material composition of a structure determine the frequency at which the object will resonate. Because most biological tissues are heavily damped, the increase in susceptibility from resonance is limited.

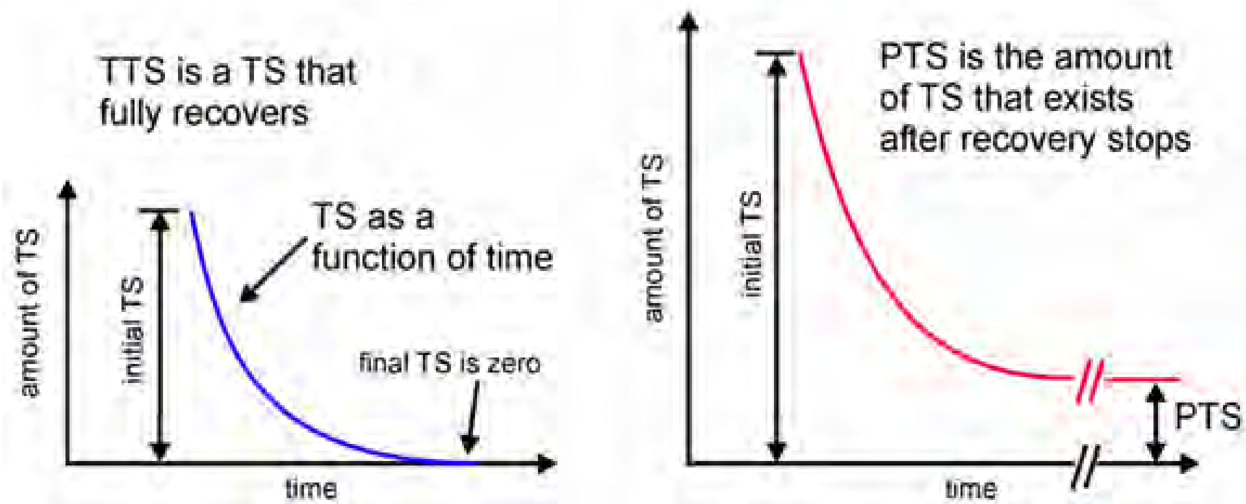
Vascular and tissue bubble formation resulting from sound exposure is a hypothesized mechanism of injury to breath-holding marine animals. Bubble formation and growth due to direct sound exposure have been hypothesized (Crum & Mao, 1996; Crum et al., 2005); however, the experimental laboratory conditions under which these phenomena were observed would not be replicated in the wild. Certain dive behaviors by breath-holding animals are predicted to result in conditions of blood nitrogen super-saturation, potentially putting an animal at risk for decompression sickness (Fahlman et al., 2014), although this phenomena has not been observed (Houser et al., 2009). In addition, animals that spend long periods of time at great depths are predicted to have super-saturated tissues that may slowly release nitrogen if the animal then spends a long time at the surface (i.e., stranding) (Houser et al., 2009).

Injury could increase the animal's physiological stress (Box B8), which feeds into the stress response (Box B7) and also increases the likelihood or severity of a behavioral response. Injury may reduce an animal's ability to secure food by reducing its mobility or the efficiency of its sensory systems, making the injured individual less attractive to potential mates, increasing an individual's chances of contracting diseases or falling prey to a predator (Box D2), or increasing an animal's overall physiological stress level (Box D10). Severe injury can lead to the death of the individual (Box D1).

Damaged tissues from mild to moderate injury may heal over time. The predicted recovery of direct injury is based on the severity of the injury, availability of resources, and characteristics of the animal. The animal may also need to recover from any potential costs due to a decrease in resource gathering efficiency and any secondary effects from predators or disease. Severe injuries can lead to reduced survivorship (longevity), elevated stress levels, and prolonged alterations in behavior that can reduce an animal's lifetime reproductive success. An animal with decreased energy stores or a lingering injury may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring produced over its lifetime.

3.0.3.6.1.2 Hearing Loss

Hearing loss, also called a noise-induced threshold shift, is possibly the best studied type of effect from sound exposures to animals. Hearing loss manifests itself as loss in hearing sensitivity across part of an animal's hearing range, which is dependent upon the specifics of the noise exposure. Hearing loss may be either PTS, or TTS. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 3.0-16 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.



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

Figure 3.0-16: Two Hypothetical Threshold Shifts

The characteristics of the received sound stimuli are used and compared to the animal's hearing sensitivity and susceptibility to noise (Box A3) to determine the potential for hearing loss. The amplitude, frequency, duration, and temporal pattern of the sound exposure are important parameters for predicting the potential for hearing loss over a specific portion of an animal's hearing range. Duration is particularly important because hearing loss increases with prolonged exposure time. Longer exposures with lower sound levels can cause more threshold shift than a shorter exposure using the same amount of energy overall. The frequency of the sound also plays an important role. Experiments show that animals are most susceptible to hearing loss (Box B3) within their most sensitive hearing range. Sounds outside of an animal's audible frequency range do not cause hearing loss.

The mechanisms responsible for hearing loss may consist of a variety of mechanical and biochemical processes in the inner ear, including physical damage or distortion of the tympanic membrane (not including tympanic membrane rupture which is considered auditory injury), physical damage or distortion of the cochlear hair cells, hair cell death, changes in cochlear blood flow, and swelling of cochlear nerve terminals (Henderson et al., 2006; Kujawa & Liberman, 2009). Although the outer hair cells are the most prominent target for fatigue effects, severe noise exposures may also result in inner hair cell death and loss of auditory nerve fibers (Henderson et al., 2006).

The relationship between TTS and PTS is complicated and poorly understood, even in humans and terrestrial mammals, where numerous studies failed to delineate a clear relationship between the two. Relatively small amounts of TTS (e.g., less than 40–50 dB measured two minutes after exposure) will recover with no apparent permanent effects; however, terrestrial mammal studies revealed that larger amounts of threshold shift can result in permanent neural degeneration, despite the hearing thresholds returning to normal (Kujawa & Liberman, 2009). The amounts of threshold shift induced by Kujawa and Liberman (2009) were described as being "at the limits of reversibility." It is unknown whether smaller amounts of threshold shift can result in similar neural degeneration, or if effects would translate to other species such as marine animals.

Hearing loss can increase an animal's physiological stress (Box B8), which feeds into the stress response (Box B7). Hearing loss may increase the likelihood or severity of a behavioral response and increase an animal's overall physiological stress level (Box D10). Hearing loss reduces the distance over which animals can communicate and detect other biologically important sounds (Box D3). Hearing loss could also be inconsequential for an animal if the frequency range affected is not critical for that animal to hear within, or the hearing loss is of such short duration (e.g., a few minutes) that there are no costs to the individual.

Small to moderate amounts of hearing loss may recover over a period of minutes to days, depending on the amount of initial threshold shift. Severe noise-induced hearing loss may not fully recover, resulting in some amount of PTS. An animal whose hearing does not recover quickly and fully could suffer a reduction in lifetime reproductive success. An animal with PTS may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring it can produce over its lifetime.

3.0.3.6.1.3 Masking

Masking occurs if the noise from an activity interferes with an animal's ability to detect, understand, or recognize biologically relevant sounds of interest (Box B4). In this context noise refers to unwanted or unimportant sounds that mask an animal's ability to hear sounds of interest. Sounds of interest include those from conspecifics such as offspring, mates, and competitors; echolocation clicks; sounds from predators; natural, abiotic sounds that may aid in navigation; and reverberation, which can give an animal information about its location and orientation within the ocean. The probability of masking increases as the noise and sound of interest increase in similarity and the masking noise increases in level. The frequency, received level, and duty cycle of the noise determines the potential degree of auditory masking. Masking only occurs during the sound exposure.

A behavior decision (either conscious or instinctive) is made by the animal when the animal detects increased background noise, or possibly, when the animal recognizes that biologically relevant sounds are being masked (Box C1). An animal's past experiences can be important in determining the behavioral response when dealing with masking (Box C4). For example, an animal may modify its vocalizations to reduce the effects of masking noise. Other stimuli present in the environment can influence an animal's behavior decision (Box C5) such as the presence of predators, prey, or potential mates.

An animal may exhibit a passive behavioral response when coping with masking (Box C2). It may simply not respond and keep conducting its current natural behavior. An animal may also stop calling until the background noise decreases. These passive responses do not present a direct energetic cost to the animal; however, masking will continue, depending on the acoustic stimuli.

An animal may actively compensate for masking (Box C3). An animal can vocalize more loudly to make its signal heard over the masking noise. An animal may also shift the frequency of its vocalizations away from the frequency of the masking noise. This shift can actually reduce the masking effect for the animal and other animals that are listening in the area.

If masking impairs an animal's ability to hear biologically important sounds (Box D3) it could reduce an animal's ability to communicate with conspecifics or reduce opportunities to detect or attract more distant mates, gain information about their physical environment, or navigate. An animal that modifies its vocalization in response to masking could also incur a cost (Box D4). Modifying vocalizations may cost the animal energy, interfere with the behavioral function of a call, or reduce a signaler's apparent quality as a mating partner. For example, songbirds that shift their calls up an octave to compensate for increased background noise attract fewer or less-desirable mates, and many terrestrial species advertise body size and quality with low-frequency vocalizations (Slabbekoorn & Ripmeester, 2007). Masking may also lead to no measurable costs for an animal. Masking could be of short duration or intermittent such that biologically important sounds that are continuous or repeated are received by the animal between masking noise.

Masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity. Masking could have long-term consequences for individuals if the activity was continuous or occurred frequently enough.

3.0.3.6.1.4 Physiological Stress

Marine animals naturally experience physiological stress as part of their normal life histories. The physiological response to a stressor, often termed the stress response, is an adaptive process that helps an animal cope with changing external and internal environmental conditions. Sound-producing activities have the potential to cause additional stress. However, too much of a stress response can be harmful to an animal, resulting in physiological dysfunction.

If a sound is detected (i.e., heard or sensed) by an animal, a stress response can occur (Box B7). The severity of the stress response depends on the received sound level at the animal (Box A2), the details of the sound-producing activity (Box A1), and the animal's life history stage (e.g., juvenile or adult, breeding or feeding season), and past experience with the stimuli (Box B5). An animal's life history stage is an important factor to consider when predicting whether a stress response is likely (Box B5). An animal's life history stage includes its level of physical maturity (i.e., larva, infant, juvenile, sexually mature adult) and the primary activity in which it is engaged such as mating, feeding, or rearing/caring for young. Prior experience with a stressor may be of particular importance because repeated experience with a stressor may dull the stress response via acclimation (St. Aubin & Dierauf, 2001) or increase the response via sensitization. Additionally, if an animal suffers injury or hearing loss, a physiological stress response will occur (Box B8).

The generalized stress response is characterized by a release of hormones (Reeder & Kramer, 2005) and other chemicals (e.g., stress markers) such as reactive oxidative compounds associated with noise-induced hearing loss (Henderson et al., 2006). Stress hormones include norepinephrine and epinephrine (i.e., the catecholamines), which produce elevations in the heart and respiration rate, increase awareness, and increase the availability of glucose and lipid for energy. Other stress hormones are the glucocorticoid steroid hormones cortisol and aldosterone, which are classically used as an indicator of a stress response and to characterize the magnitude of the stress response (Hennessy et al., 1979).

An acute stress response is traditionally considered part of the startle response and is hormonally characterized by the release of the catecholamines. Annoyance type reactions may be characterized by the release of either or both catecholamines and glucocorticoid hormones. Regardless of the physiological changes that make up the stress response, the stress response may contribute to an animal's decision to alter its behavior.

Elevated stress levels may occur whether or not an animal exhibits a behavioral response (Box D10). Even while undergoing a stress response, competing stimuli (e.g., food or mating opportunities) may overcome any behavioral response. Regardless of whether the animal displays a behavioral response, this tolerated stress could incur a cost to the animal. Reactive oxygen compounds produced during normal physiological processes are generally counterbalanced by enzymes and antioxidants; however, excess stress can lead to damage of lipids, proteins, and nucleic acids at the cellular level (Berlett & Stadtman, 1997; Sies, 1997; Touyz, 2004).

Frequent physiological stress responses may accumulate over time increasing an animal's chronic stress level. Each component of the stress response is variable in time, and stress hormones return to baseline levels at different rates. Elevated chronic stress levels are usually a result of a prolonged or repeated disturbance. Chronic elevations in the stress levels (e.g., cortisol levels) may produce long-term health consequences that can reduce lifetime reproductive success.

3.0.3.6.1.5 Behavioral Reactions

Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and many overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary drastically between minor and brief reorientations of the animal to investigate the sound, to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the cost to the animal. The total number of vehicles and platforms involved, the size of the activity area, the distance between the animal and activity, and the duration of the activity are important considerations when predicting the initial behavioral responses.

A physiological stress response (Box B7) such as an annoyance or startle reaction, or cueing or alerting (Box B6) may cause an animal to make a behavior decision (Box C6). Any exposure that produces an injury or hearing loss is also assumed to produce a stress response (Box B7) and increase the severity or likelihood of a behavioral reaction. Both an animal's experience (Box C4) and competing and reinforcing stimuli (Box C5) can affect an animal's behavior decision. The decision can result in three general types of behavioral reactions: no response (Box C9), area avoidance (Box C8), or alteration of a natural behavior (Box C7).

An animal's past experiences can be important in determining what behavior decision it may make when dealing with a stress response (Box C4). Habituation is the process by which an animal learns to ignore or tolerate stimuli over some period and return to a normal behavior pattern, perhaps after being exposed to the stimuli with no negative consequences. Sensitization is when an animal becomes more sensitive to a set of stimuli over time, perhaps as a result of a past, negative experience that could result in a stronger behavioral response.

Other stimuli (Box C5) present in the environment can influence an animal's behavioral response. These stimuli may be conspecifics or predators in the area or the drive to engage in a natural behavior. Other stimuli can also reinforce the behavioral response caused by acoustic stimuli. For example, the awareness of a predator in the area coupled with the sound-producing activity may elicit a stronger reaction than the activity alone would have.

An animal may reorient, become more vigilant, or investigate if it detects a sound-producing activity (Box C7). These behaviors all require the animal to divert attention and resources, therefore slowing or stopping their presumably beneficial natural behavior. This can be a very brief diversion, or an animal may not resume its natural behaviors until after the activity has concluded. An animal may choose to leave or avoid an area where a sound-producing activity is taking place (Box C8). A more severe form of this comes in the form of flight or evasion. Avoidance of an area can help the animal avoid further effects by avoiding or reducing further exposure. An animal may also choose not to respond to a sound-producing activity (Box C9).

An animal that alters its natural behavior in response to stress or an auditory cue may slow or cease its natural behavior and instead expend energy reacting to the sound-producing activity (Box D5). Natural behaviors include feeding, breeding, sheltering, and migrating. The cost of feeding disruptions depends on the energetic requirements of individuals and the potential amount of food missed during the disruption. Alteration in breeding behavior can result in delaying reproduction. The costs of a brief interruption to migrating or sheltering are less clear.

An animal that avoids a sound-producing activity may expend additional energy moving around the area, be displaced to poorer resources, miss potential mates, or have social interactions affected (Box D6). The amount of energy expended depends on the severity of the behavioral response. Missing potential mates can result in delaying reproduction. Groups could be separated during a severe behavioral response such as flight and offspring that depend on their parents may die if they are permanently separated. Splitting up an animal group can result in a reduced group size, which can have secondary effects on individual foraging success and susceptibility to predators.

Some severe behavioral reactions can lead to stranding (Box D7) or secondary injury (Box D8). Animals that take prolonged flight, a severe avoidance reaction, may injure themselves or strand in an environment for which they are not adapted. Some injury is likely to occur to an animal that strands (Box D8). Trauma can reduce the animal's ability to secure food and mates, and increase the animal's susceptibility to predation and disease (Box D2). An animal that strands and does not return to a hospitable environment may die (Box D9).

3.0.3.6.1.6 Long-Term Consequences

The potential long-term consequences from behavioral responses are difficult to discern. Animals displaced from their normal habitat due to an avoidance reaction may return over time and resume their natural behaviors. This is likely to depend upon the severity of the reaction and how often the activity is repeated in the area. In areas of repeated and frequent acoustic disturbance, some animals may habituate to the new baseline; conversely, species that are more sensitive may not return, or return but not resume use of the habitat in the same manner. For example, an animal may return to an area to feed but no longer rest in that area. Long-term abandonment or a change in the utilization of an area by enough individuals can change the distribution of the population. Frequent disruptions to natural behavior patterns may not allow an animal to recover between exposures, which increase the probability of causing long-term consequences to individuals.

The magnitude and type of effect and the speed and completeness of recovery (i.e., return to baseline conditions) must be considered in predicting long-term consequences to the individual animal (Box E4). The predicted recovery of the animal (Box E1) is based on the cost to the animal from any reactions, behavioral or physiological. Available resources fluctuate by season, location, and year and can play a major role in an animal's rate of recovery (Box E2). Recovery can occur more quickly if plentiful food resources, many potential mates, or refuge or shelter is available. An animal's health, energy reserves, size, life history stage, and resource gathering strategy affect its speed and completeness of recovery (Box E3). Animals that are in good health and have abundant energy reserves before an effect takes place will likely recover more quickly.

Animals that recover quickly and completely are unlikely to suffer reductions in their health or reproductive success, or experience changes in habitat utilization (Box F2). No population-level effects would be expected if individual animals do not suffer reductions in their lifetime reproductive success or change their habitat utilization (Box G2). Animals that do not recover quickly and fully could suffer reductions in their health and lifetime reproductive success; they could be permanently displaced or change how they use the environment; or they could die (Box F1). These long-term consequences to the individual can lead to consequences for the population (Box G1); although, population dynamics and abundance play a role in determining how many individuals would need to suffer long-term consequences before there was an effect on the population.

Long-term consequences to individuals can translate into consequences for populations dependent upon population abundance, structure, growth rate, and carry capacity. Carrying capacity describes the theoretical maximum number of animals of a particular species that the environment can support. When a population nears its carrying capacity, its growth is naturally limited by available resources and predator pressure. If one, or a few animals, in a population are removed or gather fewer resources, then other animals in the population can take advantage of the freed resources and potentially increase their health and lifetime reproductive success. Abundant populations that are near their carrying capacity (theoretical maximum abundance) that suffer consequences on a few individuals may not be affected overall. Populations that exist well below their carrying capacity may suffer greater consequences from any lasting consequences to even a few individuals. Population-level consequences can include a change in the population dynamics, a decrease in the growth rate, or a change in geographic distribution.

3.0.3.6.2 Conceptual Framework for Assessing Effects from Energy-Producing Activities

3.0.3.6.2.1 Stimuli

Magnitude of the Energy Stressor

Regulations do not provide threshold criteria to determine the significance of the potential effects from activities that involve the use of varying electromagnetic frequencies or lasers. Many organisms, primarily marine vertebrates, have been studied to determine their thresholds for detecting electromagnetic fields, as reviewed by Bureau of Ocean Energy Management (2011); however, there are no data on predictable responses to exposure above or below detection thresholds. The types of electromagnetic fields discussed are those from mine neutralization activities (magnetic influence minesweeping). High-energy and low-energy lasers were considered for analysis. Low-energy lasers (e.g., targeting systems, detection systems, laser light detection and ranging) do not pose a risk to organisms (U.S. Department of the Navy, 2010) and therefore will not be discussed further. Radar was also considered for analysis, and also was determined not to pose a risk to biological resources (Bruderer et al., 1999; Manville, 2016; Wiltschko et al., 2011; Wiltschko & Wiltschko, 2005).

Location of the Energy Stressor

Evaluation of potential energy exposure risks considered the spatial overlap of the resource occurrence and electromagnetic field and high-energy laser use. Wherever appropriate, specific geographic areas of potential impact were identified and the relative location of the resource with respect to the source was considered. For example, the greatest potential electromagnetic energy exposure is at the source, where intensity is greatest and the greatest potential for high energy laser exposure is at the ocean's surface, where high-energy laser intensity is greatest. All light energy, including laser light, entering the ocean becomes absorbed and scattered at a rate that is dependent on the frequency of the light. For most laser applications, the energy is rapidly reduced as the light penetrates the ocean.

Behavior of the Organism

Evaluation of potential energy exposure risk considered the behavior of the organism, especially where the organism lives and feeds (e.g., surface, water column, seafloor). The analysis for electromagnetic devices considered those species with the ability to perceive or detect electromagnetic signals. The analysis for high-energy lasers and radar particularly considered those species known to occur at or above the surface of the ocean.

3.0.3.6.2.2 Immediate Response and Costs to the Individual

Many different types of organisms (e.g., some invertebrates, fishes, sea turtles, birds, mammals) are sensitive to electromagnetic fields (Bureau of Ocean Energy Management, 2011). An organism that encounters a disturbance in an electromagnetic field could respond by moving toward the source, moving away from it, or not responding at all. The types of electromagnetic devices used in the Proposed Action simulate the electromagnetic signature of a vessel passing through the water column, so the expected response would be similar to that of vessel movement. However, since there would be no actual strike potential, a physiological response would be unlikely in most cases. Recovery of an individual from encountering electromagnetic fields would be variable, but since the physiological response would likely be minimal, as reviewed by Bureau of Ocean Energy Management (2011), any recovery time would also be minimal.

Very little data are available to analyze potential impacts on organisms from exposure to high energy lasers. For all but the highest energy lasers, the greatest laser-related concern for marine species is damage to an organism's ability to see.

3.0.3.6.2.3 Long-Term Consequences to the Individual and Population

Long-term consequences are considered in terms of a resource's existing population level, growth and mortality rates, other stressors on the resource from the Proposed Action, cumulative impacts on the resource, and the ability of the population to recover from or adapt to impacts. Impacts of multiple or repeated stressors on individuals are cumulative.

3.0.3.6.3 Conceptual Framework for Assessing Effects from Physical Disturbance or Strike

3.0.3.6.3.1 Stimuli

<u>Size and Weight of the Objects</u>

To determine the likelihood of a strike and the potential impacts on an organism or habitat that would result from a physical strike, the size and weight of the striking object relative to the organism or habitat must be considered. For example, most small organisms and early life stages would simply be displaced by the movement generated by a large object moving through, or falling into, the water, whereas a larger organism could potentially be struck by an object since it may not be displaced by the movement of the water. The weight of the object is also a factor that would determine the severity of a strike. A strike by a heavy object would be more severe than a strike by a low-weight object (e.g., a decelerator/parachute, flare end cap, or chaff canister).

<u>Location and Speed of the Objects</u>

Evaluation of potential physical disturbance or strike risk considered the spatial overlap of the resource occurrence and potential striking objects. Analysis of impacts from physical disturbance or strike stressors focuses on proposed activities that may cause an organism or habitat to be struck by an object moving through the air (e.g., aircraft), water (e.g., vessels, in-water devices, towed devices), or dropped into the water (e.g., non-explosive practice munitions and seafloor devices). The area of operation, vertical distribution, and density of these items also play central roles in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact are identified. Analysis of potential physical disturbance or strike risk also considered the speed of vessels as a measure of intensity. Some vessels move slowly, while others are capable of high speeds.

Buoyancy of the Objects

Evaluation of potential physical disturbance or strike risk in the ocean considered the buoyancy of targets or expended materials during operation, which will determine whether the object will be encountered at the surface, within the water column, or on the seafloor.

Behavior of the Organism

Evaluation of potential physical disturbance or strike risk considered where organisms occur and if they occur in the same geographic area and vertical distribution as those objects that pose strike risks.

3.0.3.6.3.2 Immediate Response and Costs to the Individual

Before being struck, some organisms would sense a pressure wave through the water and respond by remaining in place, moving away from the object, or moving toward it. An organism displaced a small distance by movements from an object falling into the water nearby would likely continue on with no response. However, others could be disturbed and may exhibit a generalized stress response. If the object actually hit the organism, direct injury in addition to stress may result. The function of the stress response in vertebrates is to rapidly raise the blood sugar level to prepare the organism to flee or fight. This generally adaptive physiological response can become a liability if the stressor persists and the organism cannot return to its baseline physiological state.

Most organisms would respond to sudden physical approach or contact by darting quickly away from the stimulus. Other species may respond by freezing in place or seeking refuge. In any case, the individual must stop whatever it was doing and divert its physiological and cognitive attention to responding to the stressor. The energy costs of reacting to a stressor depend on the specific situation, but in all cases the caloric requirements of stress reactions reduce the amount of energy available to the individual for other functions such as predator avoidance, reproduction, growth, and metabolism.

The ability of an organism to return to what it was doing following a physical strike (or near miss resulting in a stress response) is a function of fitness, genetic, and environmental factors. Some organisms are more tolerant of environmental or human-caused stressors than others and become acclimated more easily. Within a species, the rate at which an individual recovers from a physical disturbance or strike may be influenced by its age, sex, reproductive state, and general condition. An organism that has reacted to a sudden disturbance by swimming at burst speed would tire after some time; its blood hormone and sugar levels may not return to normal for 24 hours. During the recovery period, the organism may not be able to attain burst speeds and could be more vulnerable to predators. If the individual were not able to regain a steady state following exposure to a physical stressor, it may suffer depressed immune function and even death.

3.0.3.6.3.3 Long-Term Consequences to the Population

Long-term consequences are considered in terms of a resource's existing population level, growth and mortality rates, other stressors on the resource from the Proposed Action, cumulative impacts on the resource, and the ability of the population to recover from or adapt to impacts. Impacts of multiple or repeated stressors on individuals are cumulative.

3.0.3.6.4 Conceptual Framework for Assessing Effects from Entanglement

3.0.3.6.4.1 Stimuli

Physical Properties of the Objects

For an organism to become entangled in military expended materials, the materials must have certain properties, such as the ability to form loops and a high breaking strength. Some items could have a relatively low breaking strength on their own, but that breaking strength could be increased if multiple loops were wrapped around an entangled organism.

Physical Features of the Resource

The physical makeup of the organism itself is also considered when evaluating the risk of entanglement. Some species, by their size or physical features, are more susceptible to entanglement than others. For example, more rigid bodies with protruding snouts (e.g., hammerhead shark) or large, rigid fins (e.g., humpback whale) would have an increased risk of entanglement when compared to species with smoother, streamlined bodies such as lamprey or eels.

Location of the Objects

Evaluation of potential entanglement risk considered the spatial overlap of the resource occurrence and military expended materials. Distribution and density of expended items play a central role in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact are identified.

Buoyancy of Objects

Evaluation of potential entanglement risk considered the buoyancy of military expended materials to determine whether the object will be encountered within the water column (including the surface) or on the seafloor. Less buoyant materials, such as torpedo guidance wires, sink rapidly to the seafloor. More buoyant materials include less dense items (e.g., decelerators/parachutes) that are weighted and would sink slowly to the seafloor and could be entrained in currents.

Behavior of the Organism

Evaluation of potential entanglement risk considered the general behavior of the organism, including where the organism typically occurs (e.g., surface, water column, seafloor). The analysis particularly considered those species known to become entangled in nonmilitary expended materials (e.g., “marine debris”) such as fishing lines, nets, rope, and other derelict fishing gear that often entangle marine organisms.

3.0.3.6.4.2 Immediate Response and Costs to the Individual

The potential impacts of entanglement on a given organism depend on the species and size of the organism. Species that have protruding snouts, fins, or appendages are more likely to become entangled than smooth-bodied organisms. Also, items could get entangled by an organism's mouth, if caught on teeth or baleen, with the rest of the item trailing alongside the organism. Materials similar to fishing gear, which is designed to entangle an organism, would be expected to have a greater entanglement potential than other materials. An entangled organism would likely try to free itself of the entangling object and in the process may become even more entangled, possibly leading to a stress response. The net result of being entangled by an object could be disruption of the normal behavior, injury due to lacerations, and other sublethal or lethal impacts.

3.0.3.6.4.3 Long-Term Consequences to the Individual and Population

Consequences of entanglement could range from an organism successfully freeing itself from the object or remaining entangled indefinitely, possibly resulting in lacerations and other sublethal or lethal impacts. Stress responses or infection from lacerations could lead to latent mortality. The analysis will focus on reasonably foreseeable long-term consequences of the direct impact, particularly those that could impact the fitness of an individual. Changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success could have population-level impacts if enough individuals are impacted. This population-level impact would vary among species and taxonomic groups.

3.0.3.6.5 Conceptual Framework for Assessing Effects from Ingestion

3.0.3.6.5.1 Stimuli

Size of the Objects

To assess the ingestion risk from military expended materials, this analysis considered the size of the object relative to the animal's ability to swallow it. Some items are too large to be ingested (e.g., non-explosive practice bombs and most targets) and impacts from these items are not discussed further. However, these items may potentially break down into smaller ingestible pieces over time. Items that are of ingestible size when they are introduced into the environment and when they break down are carried forward for analysis within each resource section where applicable.

Location of the Objects

Evaluation of potential ingestion risk considered the spatial overlap of the resource occurrence and military expended materials. The distribution and density of expended items play a central role in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact were identified.

Buoyancy of the Objects

Evaluation of potential ingestion risk considered the buoyancy of military expended materials to determine whether the object will be encountered within the water column (including the surface) or on the seafloor. Less buoyant materials, such as solid metal materials (e.g., projectiles or munitions fragments), sink rapidly to the seafloor. More buoyant materials include less dense items (e.g., target fragments and decelerators/parachutes) that may be caught in currents and gyres or entangled in floating *Sargassum*. These materials can remain in the water column for an indefinite period of time before sinking. However, decelerators/parachutes are weighted and would generally sink, unless that sinking is suspended, in the scenario described here.

Feeding Behavior

Evaluation of potential ingestion risk considered the feeding behavior of the organism, including where (e.g., surface, water column, seafloor) and how (e.g., filter feeding) the organism feeds and what it feeds on. The analysis particularly considered those species known to ingest nonfood items (e.g., plastic or metal items).

3.0.3.6.5.2 Immediate Response and Costs to the Individual

Potential impacts of ingesting foreign objects on a given organism depend on the species and size of the organism. Species that normally eat spiny hard-bodied invertebrates would be expected to have tougher mouths and guts than those that normally feed on softer prey. Materials similar in size and shape to the normal diet of an organism may be more likely to be ingested without causing harm to the animal;

however, some general assumptions were made. Relatively small objects with smooth edges, such as shells or small-caliber projectiles, might pass through the digestive tract without causing harm. A small sharp-edged item may cause the individual immediate physical distress by tearing or cutting the mouth, throat, or stomach. If the object is rigid and large (relative to the individual's mouth and throat), it may block the throat or obstruct digestive processes. An object may even be enclosed by a cyst in the gut lining. The net result of ingesting large foreign objects is disruption of the normal feeding behavior, which could be sublethal or lethal.

3.0.3.6.5.3 Long-Term Consequences to the Individual and Population

The consequences of ingesting nonfood items could be nutrient deficiency, bioaccumulation, uptake of toxic chemicals, compaction, and mortality. The analysis focused on reasonably foreseeable long-term consequences of the direct impact, particularly those that could impact the fitness of an individual. Changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success could have population-level impacts if enough individuals were impacted. This population-level impact would vary among species and taxonomic groups.

3.0.3.6.6 Conceptual Framework for Assessing Effects from Secondary Stressors

This conceptual framework describes the potential effects to marine species exposed to stressors indirectly through impacts on habitat and prey availability (e.g., sediment or water quality, and physical disturbance). Stressors from Navy training and testing activities could pose indirect impacts to marine biological resources via indirect effects to habitat or to prey. These include indirect impacts from (1) explosives, explosives byproducts and unexploded munitions, (2) metals, (3) chemicals, and (4) transmission of disease and parasites. The methods used to determine secondary stressors on marine resources are presented below. Once a category of primary stressor has been analyzed to determine how a marine biological resource is impacted, an analysis follows of how a secondary stressor is potentially impacting a marine resource. After the secondary stressors are identified, a determination on the significance of the secondary impact is made. The same criteria to determine the level of significance for primary impacts are used for secondary stressors. In addition, it is possible for a significant primary impact to produce a beneficial indirect impact. For example, sinking exercises could generate a significant impact to the seafloor and surrounding habitats, while causing a potential beneficial secondary impact by creating hard-bottom habitat for invertebrates, producing a food source for fishes, and creating structural refuges for other biological resources.

3.0.3.6.6.1 Secondary Stressors

Impacts on Habitat

Primary impacts defined in each marine resource section were used to develop a conceptual model to predict the potential secondary stressors on each habitat or resource. This conceptual model incorporated factors such as the co-occurrence of stressors in space and time, the impacts or assessment endpoints of individual stressors (e.g., habitat alteration, changes in animal behavior or physiology, injury, mortality, or changes in human use), and the duration and intensity of the impacts of individual stressors. For example, a secondary stressor from a munitions strike could be habitat degradation. The primary impact or stressor is the actual strike on the habitat such as the seafloor, with the introduction of military expended materials, munitions, and fragments inducing further habitat degradation.

Secondary stressors can also induce additive impacts on habitats. These types of impacts are also determined by summing the individual stressors with identical and quantifiable assessment endpoints.

For example, if one stressor disturbed 0.25 NM^2 of benthic habitat, a second stressor disturbed 0.5 NM^2, and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 NM^2. For stressors with identical but not quantifiable assessment endpoints, potential additive impacts were qualitatively evaluated using available scientific knowledge and best professional judgment. Other habitat impacts such as underwater detonations were assessed by size of charge (net explosive weight), charge radius, height above the seafloor, substrate types in the area, and equations linking all these factors. The analysis also considered that impacts of underwater explosions vary with the bottom substrate type and that the secondary impacts would also be variable among substrate types.

Impacts on Prey Availability

Assessing the impacts of secondary stressors on prey availability falls into two main areas over different temporal scales: the cost to an individual over a relatively short amount of time (short-term) and the cost to an individual or population over a longer period of time (long-term).

3.0.3.6.6.2 Immediate Response and Costs to the Individual

After a primary impact was identified, an analysis of secondary stressors on that resource was initiated. This analysis examined whether indirect impacts would occur after the initial (primary) impact and at what temporal scale that secondary stressor would affect the resource (short-term or long-term). An assessment was then made as to whether the secondary stressor would impact an individual or a population. For example, an underwater explosion could impact a single resource such as a fish or multiple other species in the food web (e.g., prey species such as plankton). The analysis also took into consideration whether the primary impact affected more than an individual or single species. For example, a prey species that would be directly injured or killed by an explosive blast could draw in predators or scavengers from the surrounding waters that would feed on those organisms, and in turn could be more directly susceptible to being injured or killed by subsequent explosions. For purposes of this analysis, indirect impacts on a resource did not require trophic transfer (e.g., bioaccumulation) in order to be observed. It is important to note that the terms “indirect” and “secondary” describe how the impact may occur in an organism or its ecosystem and does not imply reduced severity of environmental consequences.

3.0.3.6.6.3 Long-Term Consequences to the Individual and Population

Long-term consequences of secondary stressors on an individual or population are often difficult to determine. Once a primary impact is identified, the severity of that impact helps to determine the temporal scale at which the secondary stressor can be measured. For most marine resources, the abundance of prey species near a detonation point would be diminished for a short period (weeks to months) before being repopulated by animals from adjacent waters. In some extreme cases, recovery of the habitat or prey resources could occur over a relatively long time frame (months to years). It is important to note that indirect impacts often differ among resources, spatial, and temporal scales.

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

TABLE OF CONTENTS

List of Figures

List of Tables

3.1 Air Quality

AIR QUALITY SYNOPSIS

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

- Criteria Air Pollutants: The emission of criteria pollutants resulting from activities in the Study Area would not cause a violation or contribute to an ongoing violation of the National Ambient Air Quality Standards.

3.1.1 Introduction

Air pollution is a threat to human health and also damages the environment (U.S. Environmental Protection Agency, 2007). Air pollution damages trees, crops, other plants, lakes, and animals. In addition to damaging the natural environment, air pollution damages the exteriors of buildings, monuments, and statues. It creates haze or smog that reduces visibility in national parks and cities and interferes with aviation. To improve air quality and reduce air pollution, Congress passed the Clean Air Act and its amendments in 1970 and 1990, which set regulatory limits on air pollutants and help to ensure basic health and environmental protection from air pollution.

Air quality is defined by ambient concentrations of specific air pollutants – pollutants the U.S. Environmental Protection Agency (USEPA) determined may affect the health or welfare of the public. The six major pollutants of concern are called “criteria pollutants”: carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, particulate matter (dust particles less than or equal to 10 microns in diameter and fine particulate matter less than or equal to 2.5 microns in diameter), and lead. The Clean Air Act required that the USEPA establish National Ambient Air Quality Standards for these criteria pollutants. These standards set specific concentration limits for criteria pollutants in the outdoor air. The concentration limits were developed because the criteria pollutants are common in outdoor air, considered harmful to public health and the environment, and come from numerous and diverse sources. The concentration limits are designed to aid in protecting public health and the environment. Areas with air pollution problems typically have one or more criteria pollutants consistently present at levels that exceed the National Ambient Air Quality Standards. These areas are designated as nonattainment for the standards.

Criteria air pollutants are classified as either primary or secondary pollutants based on how they are formed in the atmosphere. Primary air pollutants are emitted directly into the atmosphere from the source of the pollutant and retain their chemical form. Examples of primary pollutants are the smoke produced by burning wood and volatile organic compounds emitted by industrial solvents. Secondary air pollutants are those formed through atmospheric chemical reactions that usually involve primary air pollutants (or pollutant precursors) and normal constituents of the atmosphere. Ozone, a major component of photochemical smog, is a secondary air pollutant. Ozone precursors fall into two broad groups of chemicals: nitrogen oxides and volatile organic compounds. Nitrogen oxides consists of nitric oxide and nitrogen dioxide.

Finally, some criteria air pollutants are a combination of primary and secondary pollutants. Particulate matter less than or equal to 10 microns in diameter and particulate matter less than or equal to 2.5 microns in diameter are generated as primary pollutants by various mechanical processes (e.g., abrasion, erosion, mixing, or atomization) or combustion processes. They are generated as secondary pollutants through chemical reactions or through the condensation of gaseous pollutants into fine aerosols.

In addition to the six criteria pollutants, the USEPA currently designates 187 substances as hazardous air pollutants under the federal Clean Air Act. Hazardous air pollutants are air pollutants known or suspected to cause cancer or other serious health effects, or adverse environmental and ecological effects (U.S. Environmental Protection Agency, 2016a). National Ambient Air Quality Standards are not established for these pollutants; however, the USEPA developed rules that limit emissions of hazardous air pollutants from specific industrial sources. These emissions control standards are known as "maximum achievable control technologies" and "generally achievable control technologies." They are intended to achieve the maximum degree of reduction in emissions of the hazardous air pollutants, taking into consideration the cost of emissions control, non-air quality health and environmental impacts, and energy requirements. These emissions are typically one or more orders of magnitude smaller than concurrent emissions of criteria air pollutants, and only become a concern when large amounts of fuel, explosives, or other materials are consumed during a single activity or in one location. Hazardous air pollutants are analyzed qualitatively in relation to the prevalence of the sources emitting these pollutants during training and testing activities. Mobile sources operating as a result of the Proposed Action would be functioning intermittently over a large area and would produce negligible ambient hazardous air pollutants, predominantly in areas not routinely accessed by the general public. For these reasons, hazardous air pollutants are not further evaluated in the analysis. Air pollutant emissions are reported as the rate (by weight or volume) at which specific compounds are emitted into the atmosphere by a source. Most air pollutant emissions are expressed as a rate (e.g., pounds per hour, pounds per day, or tons per year). Typical units for emission factors for a source or source activity are pounds per thousand gallons of fuel burned, pounds per ton of material processed, and grams per vehicle-mile of travel.

Ambient air quality is reported as the atmospheric concentrations of specific air pollutants at a particular time and location. The units of measurement are expressed as a mass per unit volume (e.g., micrograms per cubic meter [$\mu g/m^3$] of air) or as a volume fraction (e.g., parts per million [ppm] by volume). The ambient air pollutant concentrations measured at a particular location are determined by the pollutant emissions rate, local meteorology, and atmospheric chemistry. Wind speed and direction, the vertical temperature gradient of the atmosphere, and precipitation patterns affect the dispersal, dilution, and removal of air pollutant emissions from the atmosphere.

3.1.1.1 Air Quality Standards

National Ambient Air Quality Standards for criteria pollutants are set forth in Table 3.1-1. Areas that exceed a standard are designated as "nonattainment" for that pollutant, while areas that are in compliance with a standard are in "attainment" for that pollutant. An area may be nonattainment for some pollutants and attainment for others simultaneously.

Table 3.1-1: National Ambient Air Quality Standards

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon monoxide		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead		primary and secondary	Rolling 3-month period	0.15 µg/m^3 (1)	Not to be exceeded
Nitrogen dioxide		primary	1 hour	100 parts per billion (ppb)	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual mean
Ozone		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle pollution (particulate matter)	particulate matter less than or equal to 2.5 microns in diameter	primary	1 year	12.0 µg/m^3	Annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m^3	Annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years
	particulate matter less than or equal to 10 microns in diameter	primary and secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years

Table 3.1-1: National Ambient Air Quality Standards (continued)

Pollutant	Primary/ Secondary	Averaging Time	Level	Form
Sulfur dioxide	primary	1 hour	75 ppb[(4)]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

(1) In areas designated nonattainment for the lead standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 μg/m^3 as a calendar quarter average) also remain in effect.

(2)The level of the annual nitrogen dioxide standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3)Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) ozone standards additionally remain in effect in some areas. Revocation of the previous (2008) ozone standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4)The previous sulfur dioxide standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved and which is designated nonattainment under the previous sulfur dioxide standards or is not meeting the requirements of a State Implementation Plan call under the previous sulfur dioxide standards (40 Code of Federal Regulations [CFR] 50.4(3)). A State Implementation Plan call is a USEPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the require National Ambient Air Quality Standards.

Source: (U.S. Environmental Protection Agency, 2016b), last updated January 7, 2016.

Notes: μg/m^3 = micrograms per cubic meter; ppb = parts per billion; ppm = parts per million

States, through their air quality management agencies, are required to prepare and implement State Implementation Plans for nonattainment areas, which demonstrate how the area will meet the National Ambient Air Quality Standards. Areas classified as attainment, after being designated as nonattainment, may be reclassified as maintenance areas subject to maintenance plans showing how the area will continue to meet federal air quality standards. Nonattainment areas for some criteria pollutants are further classified, depending on the severity of their air quality problem, to facilitate their management:

- ozone – marginal, moderate, serious, severe, and extreme
- carbon monoxide – moderate and serious
- particulate matter – moderate and serious

The USEPA delegates the regulation of air quality to the state once the state has an approved State Implementation Plan. If the state fails to develop an adequate plan to achieve and maintain the National Ambient Air Quality Standards or a State Implementation Plan revision is not approved by the USEPA, federal agencies must comply with the Federal Implementation Plan. States may also choose to adopt the Federal Implementation Plan as an alternative to developing their own State Implementation Plan. States may establish air quality standards more stringent than the National Ambient Air Quality Standards, however they are prohibited from imposing more stringent conformity requirements unless the requirements apply equally to non-federal activities.

The Atlantic Fleet Training and Testing (AFTT) Study Area is offshore of a number of states, and some elements of the Proposed Action occur within or over state waters. State waters extend from the shoreline to 3 nautical miles (NM) from Maine to the east coast of Florida, Alabama, Mississippi, Louisiana, and to 9 NM for the west coast of Florida and Texas. A coastal state exercises sovereignty over its territorial sea, the air space above it, and the seabed and subsoil beneath it. Some activities occur in state waters and primarily involve the use of small boats as is the case with inshore training on state waters. These activities occur in a variety of locations such as Narragansett Bay, the lower Chesapeake Bay, the James and York Rivers, Kings Bay, Cooper River, St. Johns River, and St. Andrew Bay. However, most of the Study Area is substantially offshore, beyond state boundaries where attainment status is unclassified and Clean Air Act National Ambient Air Quality Standards do not apply. There may be seasonal or other temporal fluctuations in wind direction, and during these periods, air quality in adjacent onshore areas may be affected by releases of air pollutants from mobile sources within the Study Area. Impacts at a scale that would produce demonstrable air quality impacts would typically be the result of heavy marine traffic in areas such as large ports but military activity could incrementally impact these areas. Therefore, National Ambient Air Quality Standards attainment status of adjacent onshore areas is considered in determining whether appropriate controls for air pollution sources in the adjacent offshore state waters is warranted.

In addition to coastal states, training may occur in areas proximate to U.S. territories; specifically, the U.S. Virginia Islands, Puerto Rico, Culebra and Vieques. Territorial seas for the U.S. Virgin Islands are within 3 NM of the islands. For Puerto Rico and its neighboring islands Culebra and Vieques, the territorial seas lie within 9 NM of the coast. Air quality is typically very good at all of these locations, which are heavily influenced by tradewinds and air currents induced by convection.

3.1.1.2 General Conformity Evaluation

Federal actions are required to conform with the approved State Implementation Plan for those areas of the United States designated as nonattainment or maintenance areas for any criteria air pollutant under the Clean Air Act (40 CFR parts 51 and 93). The purpose of the General Conformity Rule is to ensure that applicable federal actions, such as the Proposed Action evaluated in this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS), would not cause or contribute to a violation of an air quality standard and that the Proposed Action would not adversely affect the attainment and maintenance of National Ambient Air Quality Standards. A conformity evaluation must be completed for every applicable Navy action that generates emissions in non-attainment or maintenance areas to determine and document whether a proposed action complies with the General Conformity Rule.

In keeping with Navy guidance, the first step in evaluating the Navy action under General Conformity is to define the action, which is to conduct training activities and research, development, testing, and evaluation activities in the AFTT Study Area. This action will utilize numerous mobile sources, including aircraft, small boats, and ships, and will involve the expenditure of munitions. A detailed explanation of the proposed action can be found in Chapter 2 of this document. A significant portion of the Study Area activities would occur well offshore, but there are nearshore areas where activities will take place. One nearshore area that is located in a nonattainment area is a portion of Nassau County, which is part of the Jacksonville (Florida)-Brunswick (Georgia) Interstate Air Quality Control Region and lies adjacent to Duval County. Because a portion of the proposed Federal action will occur near a nonattainment area and the action involves the combustion of fossil fuel, an assessment has to be made as to whether or not the action is considered exempt or presumed to conform under the General Conformity Regulations.

Exempt actions are very specifically defined by USEPA, and the list of exempt actions is available at 40 CFR 93.153. The action's non-exempt direct and indirect emissions are then calculated to determine the de minimis emission levels for the applicable pollutants.

The total direct and indirect emissions is defined as the net emissions increase caused by the action considering all the emission increases and decreases that are projected to occur. The portion of emissions that are exempt or presumed to conform are not included in the total of direct and indirect emissions. The total direct and indirect emissions calculation considers all non-exempt emission increases and decreases, must be reasonably foreseeable at the time that the conformity evaluation is conducted, and the emissions considered in the calculation are within the agency's program responsibility and control (U.S. Environmental Protection Agency, 2017a).

If the total direct and indirect emissions do not exceed *de minimis* thresholds defined in the regulation, then a General Conformity Determination is not required. The *de minimis* thresholds are presented in Table 3.1-2. If these emissions equal or exceed the *de minimis* threshold values, a formal Conformity Determination must be prepared to demonstrate conformity with the USEPA-approved State Implementation Plan. If the total direct and indirect emissions do not exceed *de minimis* thresholds, then a General Conformity Determination is not required. If these emissions equal or exceed the *de minimis* threshold values, a formal Conformity Determination must be prepared to demonstrate conformity with the approved State Implementation Plan.

The Navy Guidance for Compliance with the Clean Air Act General Conformity Rule section 4.1, states that a Record of Non-Applicability must be prepared if the proposed action is subject to the Conformity Rule, but is exempt because it fits within one of the exemption categories listed under 40 CFR 93B, because the action's projected emissions are below the *de minimis* conformity applicability threshold values, or is presumed to conform (U.S. Department of the Navy, 2013).

The Clean Air Act sets out specific requirements for a group of northeast states that make up the Ozone Transport Region. States in this region are required to submit a State Implementation Plan and install a certain level of controls for the pollutants that form ozone, even if they meet the ozone standards. The Ozone Transport Region includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, and the Washington, D.C. Metropolitan Statistical Area, including the northern Virginia suburbs (Ozone Transport Commission, 2017). The Ozone Transport Region is an area subjected to poor air quality in the warm summer months resulting from ozone pollution. Contributing to the problem are local sources of air pollution as well as air pollution transported hundreds of miles from distant sources in and outside of the Ozone Transport Region. Transport most frequently originates in the Midwest and the Ohio River Valley. Note that *de minimis* levels for ozone precursors may be lower where nonattainment is a serious issue in the Ozone Transport Region. It should be noted that not all of the Ozone Transport Region has issues with attainment of the National Ambient Air Quality Standards. For example, the entire state of Rhode Island is in attainment for all criteria pollutants. However, its geographical location, as with all of the Ozone Transport Region, makes it potentially susceptible to pollutant emission incursions from other areas of the country.

Table 3.1-2: *De Minimis* Thresholds for Conformity Determinations

Pollutant	*Nonattainment or Maintenance Area Type*	*de Minimis Threshold (TPY)*
Ozone (VOC or NO_X)	Serious nonattainment	50
	Severe nonattainment	25
	Extreme nonattainment	10
	Other areas outside an Ozone Transport Region	100
Ozone (NO_X)	Marginal and moderate nonattainment inside an Ozone Transport Region	100
	Maintenance	100
Ozone (VOC)	Marginal and moderate nonattainment inside an Ozone Transport Region	50
	Maintenance within an Ozone Transport Region	50
	Maintenance outside an Ozone Transport Region	100
CO, SO_2 and NO_2	All nonattainment and maintenance	100
PM_{10}	Serious nonattainment	70
	Moderate nonattainment and maintenance	100
$PM_{2.5}$	All nonattainment and maintenance	100
Lead	All nonattainment and maintenance	25

Source: 40 CFR part 93B

Notes: CO: carbon monoxide; NO_X: nitrogen oxides; NO_2: nitrogen dioxide; PM_{10}: particulate matter ≤ 10 microns in diameter; $PM_{2.5}$: particulate matter ≤ 2.5 microns in diameter; SO_2: sulfur dioxide; SO_X: sulfur oxides; TPY: tons per year; VOC: volatile organic compound

3.1.1.2.1 Conformity Analysis in Nonattainment and Maintenance Areas

Certain Navy training and testing activities take place within nonattainment and maintenance areas. These nonattainment and maintenance areas are identified by their air quality designated areas (an area designated by the federal government where communities share a common air pollution problem). Several designated areas were identified as relevant to AFTT EIS/OEIS training or testing activities and are further discussed in Section 3.1.2.3, Existing Air Quality.

3.1.1.3 Approach to Analysis

Boundaries of Analysis

The air quality impact evaluation requires two separate analyses. Impacts of air pollutants emitted by Navy training and testing in the Atlantic Ocean, state waters, bays and inshore locations are assessed under National Environmental Policy Act (NEPA). Impacts of air pollutants emitted by Navy training and testing activities outside territorial waters are evaluated as required under Executive Order 12114.

Air pollutants emitted more than 3,000 feet (ft.) above ground level are considered to be above the atmospheric inversion layer and, therefore, do not affect ground level air quality (U.S. Environmental Protection Agency, 2009a). These emissions thus do not affect the concentrations of criteria air pollutants in the lower atmosphere, which are measured at ground level monitoring stations, and upon which federal, state, and local regulatory decisions are based. For the analysis of the effects on global climate change, however, all emissions of greenhouse gases from aircraft and vessels participating in training and testing activities, as well as targets and munitions expended, are applicable regardless of altitude (Chapter 4, Cumulative Impacts). However, because activities above 3,000 ft. for individual aircraft activities are not specifically documented, it would be impossible to analyze with any accuracy the greenhouse gases associated with testing and training activity flights above 3,000 ft. For this reason, the greenhouse gas emissions that are assessed should be understood to represent only a portion of the total emissions from aircraft flight activities.

Analysis of health-based air quality impacts under NEPA and Executive Order 12114 includes estimates of criteria air pollutants for all training and testing activities where aircraft, missiles, or targets operate at or below the aforementioned inversion layer or that involve vessels in U.S. territorial seas. The analysis of health-based air quality impacts under Executive Order 12114 includes emissions estimates of only those training and testing activities in which aircraft, missiles, or targets operate at or below 3,000 ft. above ground level, or that involve vessels outside of U.S. territorial seas. While there are a number of pierside locations associated with testing and training activities, emissions that may be generated at these locations are excluded from this analysis because they have already been previously analyzed in other NEPA documentation.

Emission Sources

Criteria air pollutants are generated by the combustion of fuel by surface vessels and by fixed-wing and rotary-wing aircraft. These mobile sources are the primary emitters of air pollution associated with testing and training activities. The emissions from these mobile sources are a function of combustion of fuel and emissions are estimated using information provided by the Navy and other reputable, sanctioned sources. Emissions are also generated by the combustion of explosives and propellants in various types of munitions. Propellants used to fire small-, medium-, and large-caliber projectiles generate criteria pollutants when detonated. Non-explosive practice munitions contain spotting charges and propellants that generate criteria air pollutants when they function. Powered targets require fuel, generating criteria air pollutants during their operation, and towed targets generate criteria air pollutants secondarily because another aircraft or vessel is required to provide power. Stationary targets may generate criteria air pollutants if all or portions of the item burn in a high-order detonation. Chaff cartridges used by ships and aircraft are launched by an explosive charge that generates small quantities of criteria air pollutants. Countermeasure flares, parachute flares, and smoke floats are designed to burn for a prescribed period, emitting criteria pollutants in the process.

The primary emissions from many munition types are carbon dioxide, carbon monoxide, and particulate matter; hazardous air pollutants are emitted at low levels (U.S. Environmental Protection Agency, 2009a).

Electronic warfare countermeasures generate emissions of chaff, a form of particulate not regulated under the federal Clean Air Act as a criteria air pollutant because virtually all radio frequency chaff is 10 to 100 times larger than particulate matter less than or equal to 10 microns in diameter (PM_{10}) (U.S. Department of the Navy, 1999). The types of training and testing that produce these other emissions may take place throughout the Study Area, but occur primarily within special use airspace. Chaff emissions during training and testing primarily occur 3 NM or more from shore and at altitudes over 3,000 ft. (above the mixing layer). Chaff released over the ocean would disperse in the atmosphere and then settle onto the ocean surface.

A study at Naval Air Station Fallon found that the release of 50,000 cartridges of chaff per year over 10,000 square miles (m^2) would result in an annual average concentration of 0.018 $\mu g/m^3$ for regulated particulate matter. This is far below the National Ambient Air Quality Standards. Similar predictions were made for St. Mary's County, Maryland (on the Chesapeake Bay), where chaff releases contribute no more than 0.008 percent of total particulate matter emissions (Arfsten et al., 2001). Therefore, chaff is not further evaluated as an air quality stressor in this EIS/OEIS.

3.1.1.3.1 Analysis Framework

Emissions sources and the approach used to estimate emissions under Alternative 1 and Alternative 2 for the air quality analysis are based, wherever possible, on information from Navy subject matter experts and established training and testing requirements. These data were used to estimate the numbers and types of aircraft, surface ships and vessels, submarines, and munitions (i.e., potential sources of air emissions) that would be involved in training and testing activities under each alternative. Emissions were assessed to identify any possibility for the magnitude of Proposed Action emissions to result in a violation of one or more National Ambient Air Quality Standards. The pollutants for which calculations are made include exhaust total hydrocarbons, carbon monoxide, nitrogen oxides, particulate matter, carbon dioxide, and sulfur dioxide and carbon dioxide.

The NEPA analysis includes a separate section for a Clean Air Act General Conformity Applicability Analysis to support a determination pursuant to the General Conformity Rule (40 CFR part 93B). This analysis focuses on training and testing activities that could impact nonattainment or maintenance areas within the region of influence. As noted above, the Study Area lies partly within or adjacent to some air quality designated areas. To evaluate whether or not the General Conformity Rule applies, air pollutant emissions associated with the Proposed Action within the applicable designated nonattainment or maintenance areas are estimated, based on the distribution of mobile source activity in state waters and mobile source activity beyond state waters. The proposed training and testing activities within this portion of the Study Area are then compared to the General Conformity Rule *de minimis* thresholds.

3.1.1.4 Emission Estimates

3.1.1.4.1 Aircraft Activities

To estimate aircraft emissions, the operating modes, number of hours of operation, and type of engine for each type of aircraft were evaluated.

Emissions associated with airfield or air station operations ashore are analyzed within the home basing environmental planning process (e.g., environmental impact statements or environmental assessments for (1) *Introduction of F/A-18 E/F (Super Hornet) Aircraft to the East Coast of the United States* (U.S. Department of the Navy, 2003); (2) *Supplemental Environmental Impact Statement for the Introduction of the P-8A Multi-Mission Aircraft into the U.S. Navy Fleet* (U.S. Department of the Navy, 2014); (3) *Transition of E-2C Hawkeye to E-2D Advanced Hawkeye at Naval Station Norfolk, Virginia, and Naval Base Ventura County Point Mugu, California* (U.S. Department of the Navy, 2009), and (4) *F-35B East Coast Basing Environmental Impact Statement)* (U.S. Department of the Navy, 2010). All fixed-wing aircraft are assumed to travel to and from training and testing ranges at or above 3,000 ft. above mean sea level and, therefore, their transits to and from the ranges do not affect surface air quality. Air combat maneuvers and air-to-air missile exercises are primarily conducted at altitudes well in excess of 3,000 ft. above mean sea level and, therefore, are not included in the estimated emissions of criteria air pollutants. Activities or portions of those training or testing activities occurring below 3,000 ft. are included in emissions estimates. Examples of activities typically occurring below 3,000 ft. include those involving helicopter platforms such as mine warfare, surface warfare, and anti-submarine warfare training and testing activities. The number of all training and testing activities and the estimated time spent above or below 3,000 ft. for calculation purposes is included in the air quality emissions estimates presented in Appendix C (Air Quality Emissions Calculations and Record of Non-Applicability).

The types of aircraft identified include the typical aircraft platforms that conduct a particular training or testing exercise (or the closest surrogate when information is not available), including range support aircraft (e.g., non-Navy commercial air services). Estimates of future aircraft sorties are based on evolutionary changes in the Navy's force structure and mission assignments. Where there are no major changes in types of aircraft, future activity levels are estimated from the distribution of baseline activities. The types of aircraft used in each training or testing activity along with hours operated in the mission activity, as well as data on landings and take-offs from ships, and numbers of sorties flown by such aircraft are presented in Appendix C (Air Quality Emissions Calculations).

Several testing activities are similar to training activities, and therefore similar assumptions were made for such activities in terms of aircraft type, altitude, and flight duration. Table 2.3-3 lists Naval Air Systems Command testing activities similar to certain training activities. Where aircraft testing activities were dissimilar to training activities, assumptions for time on ranges, and landing and takeoff information were derived by Navy subject matter experts.

Air pollutant emissions from aircraft were primarily estimated based on the training and testing hours provided by subject matter experts, as well as emission indices published in the Navy's Aircraft Environmental Support Office Memorandum Reports for individual aircraft categories. When Aircraft Environmental Support Office emission factor data were not available, emission factors were obtained from other published sources.

The emissions calculations performed for each alternative conservatively assume that each aircraft training and testing activity listed in Tables 2.3-1 to 2.3-4 is separately conducted. In practice, a testing activity may be conducted during a training flight. It is also probable that two or more training activities may be conducted during one flight (e.g., chaff or flare exercises may occur during electronic warfare activities; or air-to-surface gunnery and air-to-surface bombing activities may occur during a single flight operation). Conservative assumptions may produce elevated aircraft emissions calculations but account for the possibility, however remote, that each aircraft training and testing activity is separately conducted.

3.1.1.4.2 Military Vessel Activities

Military vessel traffic in the Study Area includes military ships and smaller boats providing services for military training and testing activities. The methods for estimating military ship emissions involve evaluating the type of activity, generating the average steaming hours for ships in each operational area, both within state waters and beyond state waters. This was done to create annual averages for the years 2010 through 2015. The average annual hours were used for Alternative 1. Alternative 1 reflects a representative year of training to account for the natural fluctuation of training cycles and deployment schedules that generally influence the maximum level of training that may occur year after year in any 5-year period. For Alternative 2, the year with the highest number of operational hours (2011) was selected as the year to represent maximum operations. Alternative 2 reflects the maximum number of training activities that could occur within a given year and assumes that the maximum level of activity would occur every year over any 5-year period. For both alternatives, the hourly data was used with data from the Naval Sea Systems Command database, Navy and Military Sealift Command Marine Engine Fuel Consumption and Emission Calculator to calculate the emissions from the propulsion and onboard generation systems. Data from the calculator included emission factors for each type of propulsion and type of onboard generator by ship type, as well as the fuel used and applicable power levels. The types of ships and numbers of activities for Alternatives 1 and 2 are derived from range records and Navy subject matter experts regarding ship participant data. Estimates of future ship activities are based on anticipated evolutionary changes in the Navy's force structure and mission assignments. Where there are no major changes in types of ships, estimates of future activities are based on the historical distribution of ship activities. The resulting calculations provided information on the time spent at each power level in each part of the Study Area, emission factors for that power level (in pounds of pollutant per hour), and total emissions for each marine vessel for each operational type and mode.

Small boat emissions were estimated based on activity data provided by the Navy, which included the type and number of small boats, locations, and total number of hours running. Each alternative conservatively assumes that small boat training and testing activities are separately conducted and separately produces emissions. In practice, multiple training/testing activities may be conducted during one training/testing event. Conservative assumptions may produce elevated vessel emissions calculations but account for the possibility, however remote, that each training and testing activity is separately conducted.

Emissions factor data came from the Naval Sea Systems Command database, Navy and Military Sealift Command Marine Engine Fuel Consumption and Emission Calculator. For non-road engines, 100 percent of all of the particulate matter less than or equal to 10 microns in diameter from gasoline and diesel-fueled engines is assumed to be particulate matter less than or equal to 2.5 microns in diameter (U.S. Environmental Protection Agency, 2010).

3.1.1.4.3 Submarine Activities

No U.S. submarines burn fossil fuel under normal operating conditions. However, testing of the emergency diesel generator or training practice of emergency conditions can result in the generator running. For this reason, the emergency generator emissions have been included for submarines, conservatively estimated for steaming hours. This overestimates the actual emissions, but ensures the occasional running of emergency diesel generators is documented as an emission.

3.1.1.4.4 Naval Gunfire, Missiles, Bombs, Other Munitions, and Military Expended Material

Naval gunfire, missiles, bombs, and other types of munitions used in training and testing activities emit air pollutants. To estimate the amounts of air pollutants emitted by munitions during their use, the numbers and types of munitions used during training or testing activities are first totaled. Then generally accepted emissions factors (U.S. Environmental Protection Agency, 2009a) for criteria air pollutants are applied to the total amounts. Finally, the total amounts of air pollutants emitted by each munition type are summed to produce total amounts of each criteria air pollutant under each alternative.

3.1.1.5 Climate Change

Greenhouse gases are compounds that contribute to the greenhouse effect—a natural phenomenon in which gases trap heat within the lowest portion of the earth’s atmosphere (surface-troposphere system), causing heating (radiative forcing) at the surface of the earth. The primary long-lived greenhouse gases directly emitted by human activities are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, nitrogen trifluoride, and sulfur hexafluoride. Carbon dioxide, methane, and nitrous oxide occur naturally in the atmosphere. These gases influence the global climate by trapping heat in the atmosphere that would otherwise escape to space. The heating effect from these gases is considered the primary cause of the global warming observed over the last 50 years (U.S. Environmental Protection Agency, 2009b). Global warming and climate change affect many aspects of the environment.

The administrator of the USEPA determined that six greenhouse gases in combination endanger both the public health and the public welfare of current and future generations. The USEPA specifically identified carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride as greenhouse gases (U.S. Environmental Protection Agency, 2009c).

To estimate global warming potential, which is the heat trapping capacity of a gas, the United States quantifies greenhouse gas emissions using the 100-year timeframe values established in the Intergovernmental Panel on Climate Change Fourth Assessment Report (Intergovernmental Panel on Climate Change, 2007), in accordance with United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change, 2013) reporting procedures. All global warming potentials are expressed relative to a reference gas, carbon dioxide, which is assigned a global warming potential equal to 1. Six other primary greenhouse gases have global warming potentials: 25 for methane, 298 for nitrous oxide, 124 to 14,800 for hydrofluorocarbons, 7,390 to greater than 17,340 for perfluorocarbons, 17,200 for nitrogen trifluoride, and up to 22,800 for sulfur hexafluoride. To estimate the carbon dioxide equivalency of a non-carbon dioxide greenhouse gas, the appropriate global warming potential of that gas is multiplied by the amount of the gas emitted. All seven greenhouse gases are multiplied by their global warming potential and the results are added to calculate the total equivalent emissions of carbon dioxide. The dominant greenhouse gas emitted is carbon dioxide, mostly from fossil fuel combustion (85.4 percent) (U.S. Environmental Protection Agency, 2016c). Weighted by global warming potential, methane is the second largest component of emissions, followed by nitrous oxide. Global warming potential-weighted emissions are presented in terms of equivalent emissions of carbon dioxide, using units of metric tonnes. The Proposed Action is anticipated to release greenhouse gases to the atmosphere. These emissions are quantified (primarily using methods elaborated upon in the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2014) for the proposed Navy training and testing in the Study Area, and estimates are presented in Chapter 4 (Cumulative Impacts) (U.S. Environmental Protection Agency, 2016c).

The potential effects of proposed greenhouse gas emissions are by nature global and may result in cumulative impacts because most individual sources of greenhouse gas emissions are not large enough to have any noticeable effect on climate change. Therefore, the impact of proposed greenhouse gas emissions to climate change is discussed in the context of cumulative impacts.

3.1.1.6 Other Compliance Considerations, Requirements, and Practices

Executive Order 13834, *Executive Order Regarding Efficient Federal Operations,* issued on May 17, 2018, establishes policy for federal agencies to prioritize actions that reduce waste, cut costs, enhance the resilience of Federal infrastructure and operations, and enable more effective accomplishment of their missions..

In January 2018, the Department of Defense (DoD) published the results of a global screening level assessment of installation vulnerabilities to climate-related security risks with the goal of identifying serious vulnerabilities and developing necessary adaptation strategies. The survey evaluated risk from flooding, extreme temperatures, wind, drought and wildfire.

In June 2014, DoD released the 2014 Climate Change Adaptation Roadmap to document DoD's efforts to plan for the changes that are occurring or expected to occur as a result of climate change. The Roadmap provides an overview and specific details on how DoD's adaptation will occur and describes ongoing efforts (U.S. Department of Defense, 2014). The Navy is committed to improving energy security and environmental stewardship by reducing reliance on fossil fuels. The Navy is actively developing and participating in energy, environmental, and climate change initiatives that will increase use of alternative energy and reduce emissions of greenhouse gases. The Navy has adopted energy, environmental, and climate change goals. These goals include increasing alternative energy use Navy-wide to 50 percent by 2020; reducing non-tactical petroleum use; ensuring environmentally sound acquisition practices; ensuring environmentally compliant operations for ships, submarines, aircraft, and facilities operated by the Navy; and implementing applicable elements of the Climate Change Adaptation Roadmap.

Equipment used by military units in the Study Area, including ships and other marine vessels, aircraft, and other equipment, are properly maintained and fueled in accordance with applicable Navy requirements. Operating equipment meets federal and state emission standards, where applicable.

3.1.2 Affected Environment

3.1.2.1 General Background

3.1.2.1.1 Region of Influence

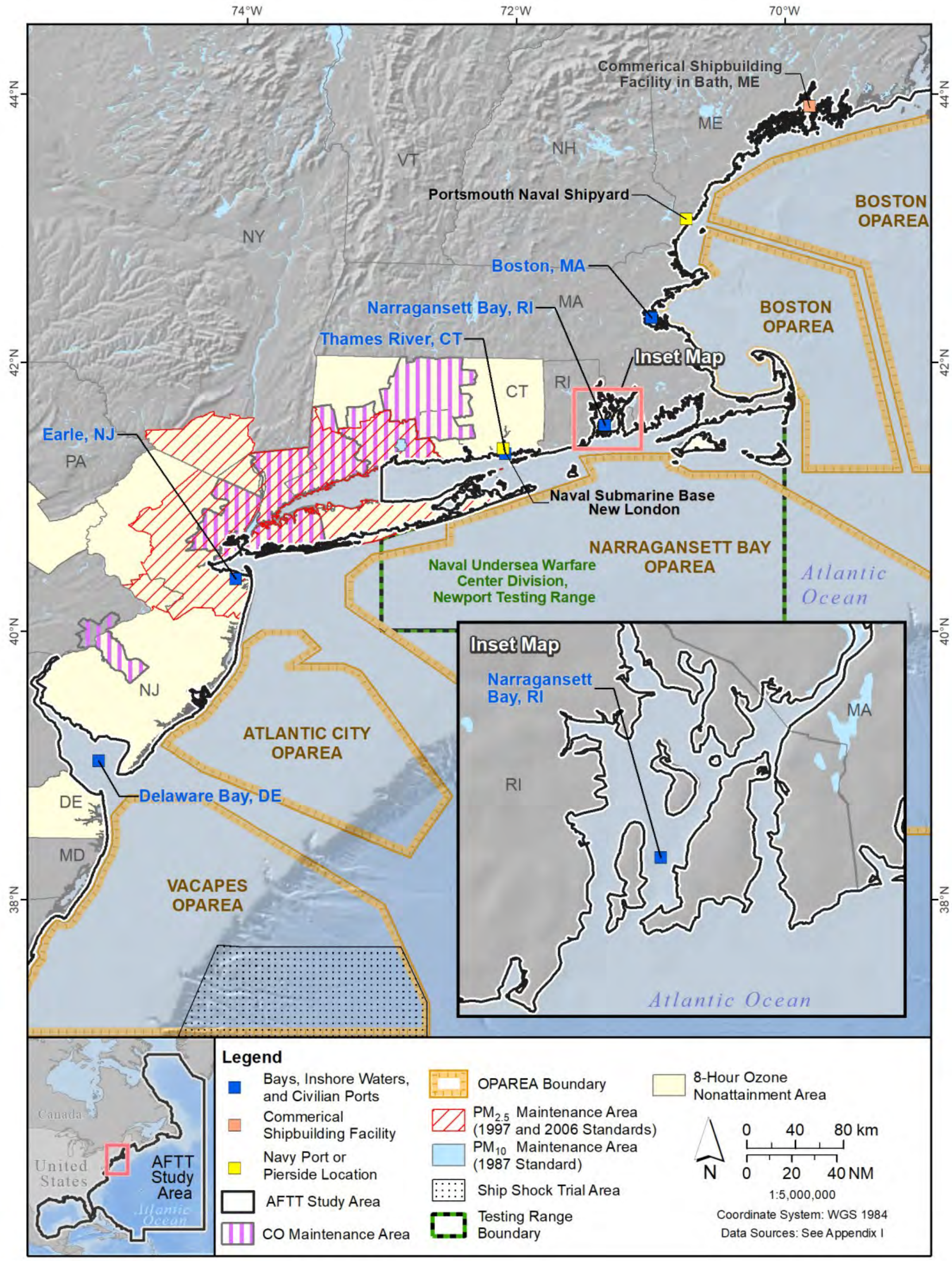
The region of influence for air quality is a function of the type of pollutant, emission rates of the pollutant source, proximity to other emission sources, and local and regional meteorology. Figure 3.1-1 through Figure 3.1-4 present maps of the nonattainment and maintenance areas in the vicinity of the Study Area. For inert pollutants (all pollutants other than ozone and its precursors), the region of influence is generally limited to a few miles downwind from the source. For a photochemical pollutant such as ozone, however, the region of influence may extend much farther downwind. Ozone is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants, or precursors (volatile organic compounds and nitrogen oxides). The maximum impacts of precursors on ozone levels tend to occur several hours after the time of emission during periods of high solar load, and may occur many miles from the source. Ozone and ozone precursors transported from other regions can also combine with local emissions to produce high local ozone concentrations. Therefore, the region of influence for air quality includes the Study Area as well as adjoining land areas several miles inland, which may from time to time be downwind from emission sources associated with the Proposed Action.

3.1.2.2 Sensitive Receptors

Identification of sensitive receptors is part of describing the existing air quality environment. Sensitive receptors are individuals in residential areas, schools, parks, hospitals, or other sites for which there is a reasonable expectation of continuous human exposure during the timeframe coinciding with peak pollution concentrations. On the oceanic portions of the Study Area, crews of commercial vessels and recreational users of the northern Atlantic Ocean and Gulf of Mexico could encounter the air pollutants generated by the Proposed Action. Few such individuals are expected to be present and the duration of substantial exposure to these pollutants is limited because the areas are cleared of nonparticipants before event commencement. These potential receptors are not considered sensitive.

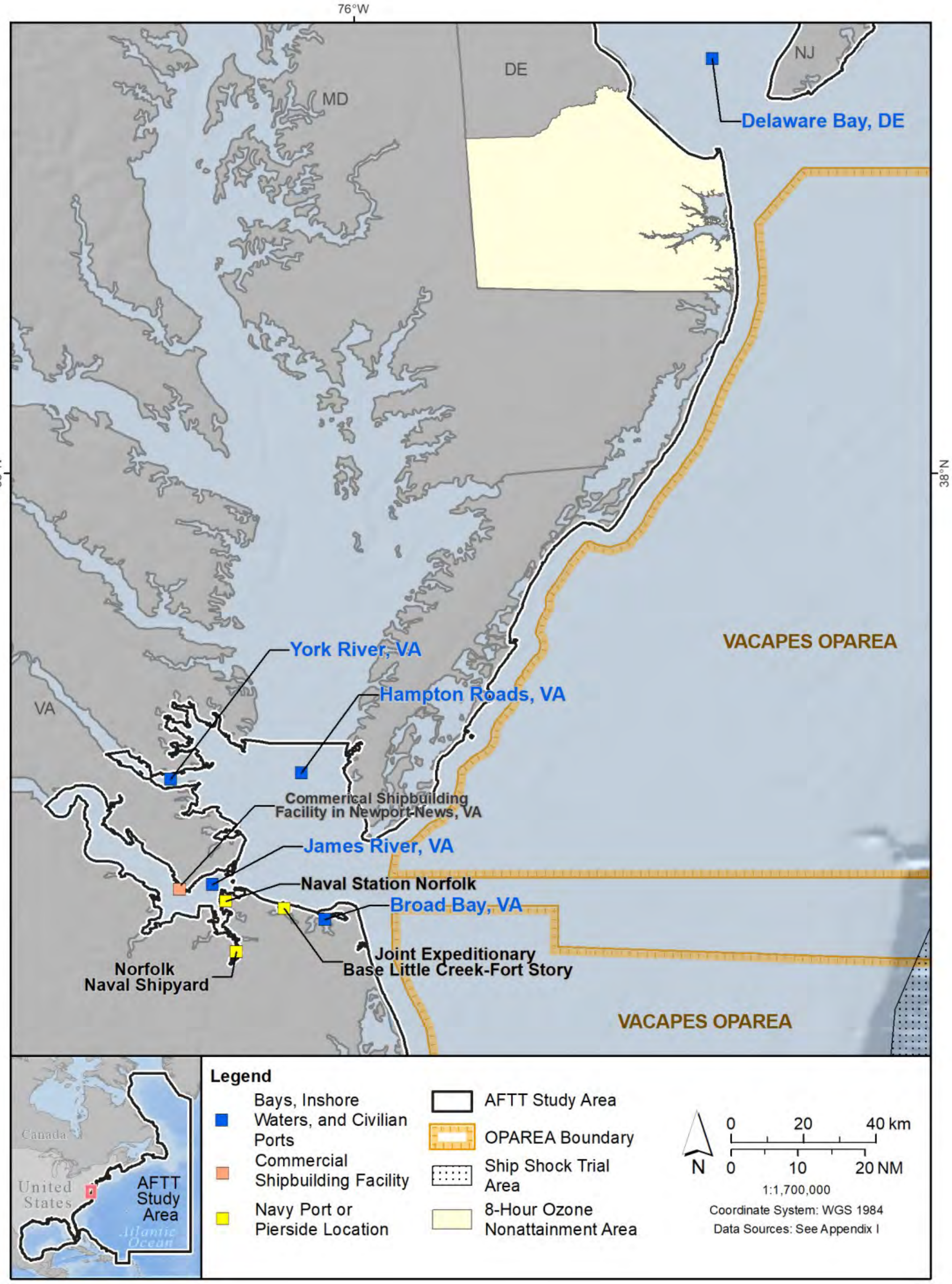
3.1.2.2.1 Climate of the Study Area

The climatic conditions in the Study Area provide background on factors influencing air quality. Climate zones within the Study Area vary with latitude or region. For air quality, the Study Area can be divided into four areas: the North Atlantic Region (Arctic region to Nova Scotia), the Mid-Atlantic Region (Maine to Virginia), the Southeast Atlantic Region (North Carolina to southern Florida) and the Gulf of Mexico Region (southern Florida to Texas).



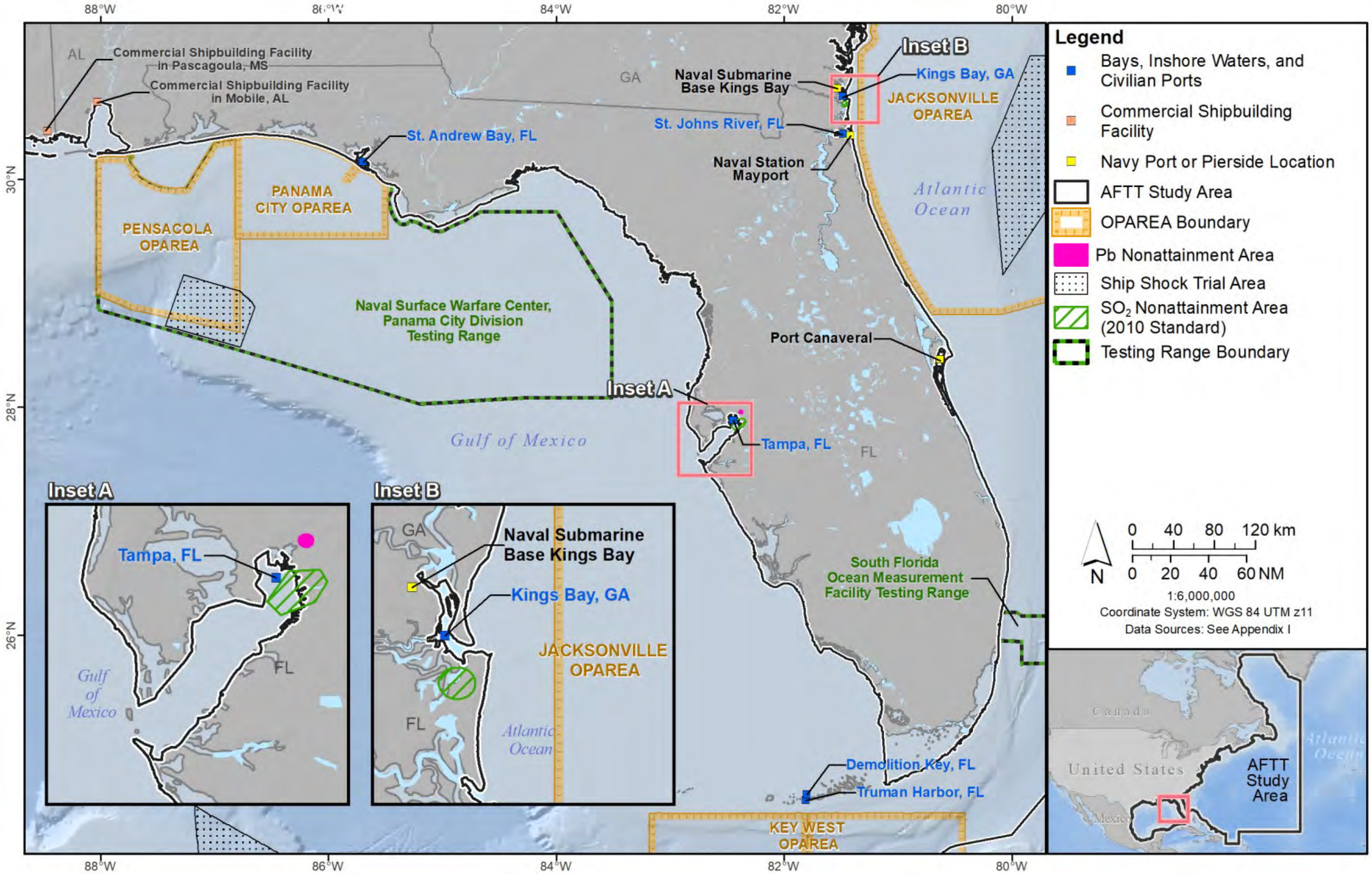
Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operation Area; VACAPES: Virginia Capes; $PM_{2.5}$: particulate matter less than or equal to 2.5 microns in diameter; PM_{10}: particulate matter less than or equal to 10 microns in diameter.

Figure 3.1-1: Applicable Nonattainment and Maintenance Areas in USEPA Region 1 and 2



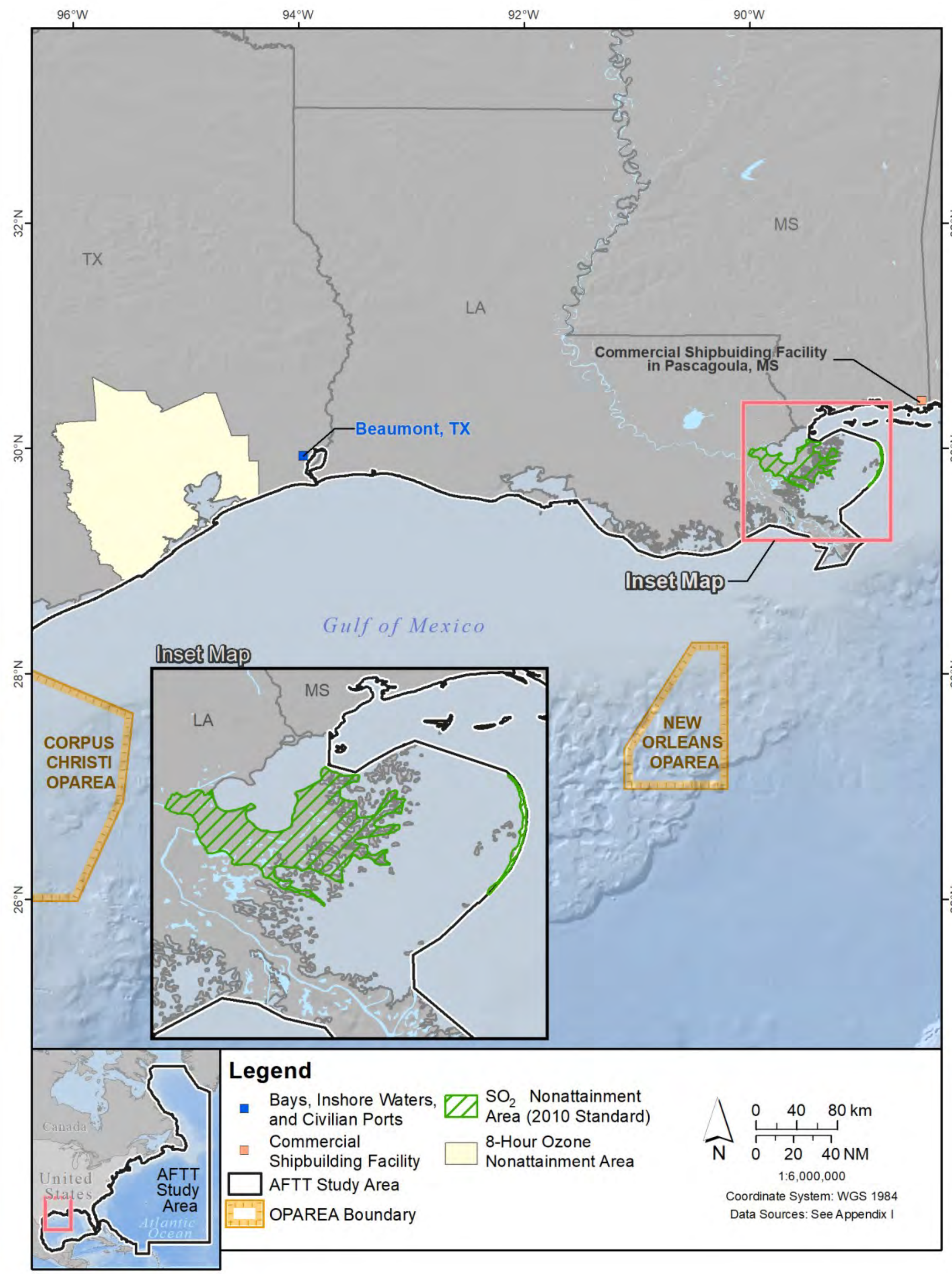
Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operation Area; VACAPES: Virginia Capes; PM $_{2.5}$: particulate matter less than or equal to 2.5 microns.

Figure 3.1-2: Applicable Nonattainment and Maintenance Areas in USEPA Region 3



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operation Area; SO_2: sulfur dioxide; Pb: lead.

Figure 3.1-3: Applicable Nonattainment and Maintenance Areas in USEPA Region 4



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operation Area: SO_2: sulfur dioxide

Figure 3.1-4: Applicable Nonattainment and Maintenance Areas in USEPA Region 6

The climate is arctic near the 65-degree north latitude line and tropical at the 20-degree north latitude line, but most activities and their potential effects would occur in the northern temperate to subtropical climate zones between Maine, Florida, and the Gulf Coast.

The climate of the offshore Atlantic Ocean and adjacent land areas is influenced by the temperatures of the surface waters and water currents as well as by wind blowing across the water. Offshore climates are moderate and seldom have extreme seasonal variations because the ocean is slow to change temperature. Ocean currents of the Atlantic Ocean (i.e., Labrador, Gulf Stream, North Atlantic Drift, Canary, and North Equatorial) influence climate by moving warm and cold water between regions. Adjacent land areas are affected by wind that is cooled or warmed when blowing over these currents. In addition to its influence on temperature, the wind moves evaporated moisture from the ocean to adjacent land areas and is a major source of rainfall.

With the advent of human induced climate change, spatial and temporal variations in weather patterns have emerged or have become more pronounced. Very heavy precipitation events have increased across the eastern half of the United States, with the most pronounced increase involving the mid-Atlantic and New England states (Melillo et al., 2014). Other changes apparent along the eastern seaboard include the rising incidence of heat waves and their extended duration and coastal flooding due to sea level rise and storm surge. In the South and along the Gulf Coast, the incidence of extreme storms, such as hurricanes, continues to rise. These changes to weather patterns have long-term consequences for regional climates and the flora and fauna of the regions.

3.1.2.2.1.1 Newfoundland-Labrador Shelf and Scotian Shelf

The Newfoundland-Labrador Shelf and Scotian Shelf are not connected to the continental United States and do not include state waters, but do fall within the AFTT Study Area. This area does not fall under the purview of the Clean Air Act and, therefore, is not included in the regulatory air quality analysis. In the North Atlantic (Newfoundland-Labrador Shelf and Scotian Shelf) winter begins (when daily temperatures average 32° Fahrenheit [° F]) as early as mid-August in the Labrador Sea or as late as October 1 off the coast of the island of Newfoundland (Canadian Coast Guard, 2010). Winter ends in this region in mid-June. Sea ice begins to grow shortly after the onset of winter as average sea temperatures reach 29° to 35° F. Polar lows usually occur during the fall, winter, and early spring.

3.1.2.2.1.2 Mid-Atlantic United States Continental Shelf

Along the coasts of Maine to Virginia, the most frequent wind directions measured by buoys are from the west or west-northwest, but wind can come from any direction (National Oceanic and Atmospheric Administration, 2017). The average wind speeds are between 12.4 and 16.2 miles per hour (mph). Wind speeds are typically lowest in July at 9.0 to 12.1 mph, and highest in January at 15.7 to 20.0 mph.

Annual average air temperature ranges from 47° to 68° F along the coast of Maine to Virginia (National Oceanic and Atmospheric Administration, 2017). Seasonal variations in temperature are greatest during the winter months. In January and February, the ambient temperature average ranges from 28° F along the coast of Maine to 52° F in Virginia. During the warmer months, there is little daily variation in temperature. In August, the average temperature is 75° F along the coast of this region.

Along the coasts of Maine to Virginia, precipitation is frequent and abundant but occurs evenly throughout the year (Minerals Management Service, 2007a). Average annual rainfall along the Atlantic coast is about 42 inches (in.). Rainfall in the warmer months is usually associated with cloud systems that produce showers and thunderstorms. Winter rains are associated with the passage of frontal systems through the eastern seaboard. Precipitation also falls as snow along the coasts of Maine to the highlands of Virginia. The highest snowfall among coastal U.S. areas within the Study Area occurs in Portland, Maine, with a maximum yearly average of 62.4 in.

3.1.2.2.1.3 Southeast United States Continental Shelf

Off the coast of North Carolina, the prevailing winds are from south to southwest, with average wind speeds between 13 to 16 mph. Off the coasts of South Carolina and Georgia, the prevailing wind direction is from south to southwest, and from southeast to east-southeast off of Florida. Average wind speeds range from 12 to 14 mph and wind speeds exhibit smaller monthly variations than northern coastal states.

Annual average air temperatures range from 70° to 75° F along the coast of the Southeast U.S. Continental Shelf (National Oceanic and Atmospheric Administration, 2017). In January and February, ambient temperatures average 55°F along the coast of the Southeast U.S. Continental Shelf. During the warmer months, there is little daily variation in temperature. In August, average temperatures are 83° F along the coast of this region. Air temperatures over the southern coast and offshore Atlantic Ocean have smaller daily and seasonal ranges than temperatures over inland areas because the ocean, which is slow to change temperature, has a stabilizing influence on ocean and coastal atmospheric temperatures.

At various locations along the Atlantic coast, fog occurs occasionally in the cooler months as a result of warm, moist air from the Gulf of Mexico blowing over cool land or water surfaces. The poorest visibility occurs from November through April. During periods of air stagnation, industrial pollution and agricultural burning also can affect visibility.

In the Southeast U.S. Continental Shelf coastal areas (generally from North Carolina to Florida), precipitation is frequent and abundant throughout the year, but tends to peak in the summer months.

Hurricanes develop in the southern part of the Atlantic Ocean. Hurricane season in the Atlantic Ocean runs from June to November, with a peak in mid-September. Most storms form in warm waters several hundred miles north of the equator. Once a tropical system forms, it usually travels west and slightly north while strengthening. Many storms curve to the northeast near the Florida peninsula. The Atlantic basin averages about 10 storms of tropical storm strength or greater per year; about half reach hurricane level (National Oceanic and Atmospheric Administration, 2005). Storms weaken as they encounter cooler water, land, or vertical wind shear, sometimes slowing to an extra-tropical storm, mostly affecting northern Atlantic coastal areas.

3.1.2.2.1.4 Gulf of Mexico

The climate of the Gulf of Mexico is influenced mainly by the clockwise circulation around the semi-permanent area of high barometric pressure commonly known as the Bermuda High (Minerals Management Service, 2002). The Gulf of Mexico is southwest of this center of circulation. This high-pressure system results in a predominantly southeasterly wind flow in the Gulf of Mexico. Two important classes of storms occasionally occur with this circulation pattern. During the winter months, cold fronts associated with cold air masses from land influence the northern coast of the Gulf of Mexico. Behind the fronts, strong north winds bring drier air into the region. Secondly, hurricanes may develop in or migrate into the Gulf of Mexico during the warmer months. These storms may affect any area of the Gulf of Mexico and substantially change the local wind circulation around them. In coastal areas, the sea breeze may become the primary circulation feature during the summer months. Conversely, land breezes (particularly at night) transport air pollutants from land to offshore areas. Locally, the land breeze diminishes as more heat is retained within large, growing coastal cities (National Science Foundation, 2011). In general, however, the subtropical maritime climate is the dominant feature driving all aspects of the weather in this region. As a result, the climate shows very little daily or seasonal variation (Minerals Management Service, 2002).

Average air temperatures at Gulf of Mexico coastal locations (Texas to Florida) vary with latitude and exposure. Air temperatures range from highs in the summer of 88° to 96° F to lows in the winter of 37° to 59° F (Minerals Management Service, 2002). Temperatures depend on the frequency and intensity of polar air masses from the north. Air temperatures over the open waters of the Gulf of Mexico are more moderate and have smaller daily and seasonal temperature ranges than land temperatures because the Gulf of Mexico is slow to change temperature (Minerals Management Service, 2007b). The average temperature over the center of the Gulf of Mexico is about 84° F in the summer and between 63° to 73° F in the winter (Minerals Management Service, 2007b).

In the Gulf of Mexico portion of the Study Area, precipitation is frequent and abundant throughout the year (Minerals Management Service, 2002). Stations along the entire Gulf Coast record the highest precipitation values during the warmer months of the year. The warmer months usually have cloud systems that produce showers and thunderstorms; however, these thunderstorms rarely cause any damage or have hail (Minerals Management Service, 2002). The month of maximum rainfall for most locations in the Gulf of Mexico is July. Winter rains often come with frontal systems passing through the area. Rainfall is generally light, steady, and relatively continuous, often lasting several days. Snowfall is rare, and when snow or sleet does occur, it usually melts on contact with the ground. The chance for snow or sleet decreases with distance from shore, rapidly reaching zero.

Hurricanes affecting the Gulf of Mexico form near the equator in the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico (Minerals Management Service, 2002). Data from 1886 to 1986 show that almost half (44.5 percent) of these hurricanes, or 3.7 storms per year, will affect the Gulf of Mexico (Minerals Management Service, 2002).

3.1.2.3 Existing Air Quality

As a whole, the air quality of the Study Area is very good. As shown in Figure 3.1-1 through Figure 3.1-3, most nonattainment and maintenance areas in the eastern half of the continental United States are in the northeastern states. Many are located in inland, urban, industrialized areas. This limited geographical extent with regard to potential air pollution results from the relatively low number of air pollutant sources, size, and topography of the Study Area, and prevailing meteorological conditions. In general, the coastal counties of the lower-middle and southern Atlantic as well as the Gulf of Mexico, including the Hampton Roads Intrastate area (in the vicinity of Naval Station Norfolk on Figure 3.1-2), are in attainment of the National Ambient Air Quality Standards. Being in attainment means that the areas maintain air quality better than the National Ambient Air Quality Standards.

Some other coastal areas, however, are either in nonattainment or are a designated maintenance area for one or more of the criteria pollutants. These designations are based on air quality data collected from monitors at locations in urban and rural setting, as well as modeling. Based on available information, the USEPA designates an area as attainment, maintenance, nonattainment, or if there is a lack of available monitoring data for the area, it may be designated unclassifiable. Nonattainment and maintenance designations range from as small as a single location to large multi-state regions. Table 3.1-3 identifies the nonattainment and maintenance areas that are adjacent to the Study Area.

Table 3.1-3: Nonattainment and Maintenance Areas Adjacent to Study Area

Area Name	*Coastal Locations Included*	*Designation*
USEPA Regions 1 & 2		
Central New Hampshire, NH	Rockingham County (p), Hillsborough County (p)	2010 SO_2 (n)
Greater Connecticut	New London County	Ozone (n-moderate)
Hartford –New Britain-Middletown, CT	Middlesex County CT (p)	CO (m)
New Haven-Meriden-Waterbury, CT	New Haven County CT	CO (m)
New York-Northern New Jersey-Long Island, NY-NJ-CT	Fairfield, New Haven & Middlesex Counties (CT); Bronx, Kings, Nassau, New York, Queens, Richmond, Rockland, Suffolk, & Westchester Counties (NY); Bergen, Essex, Hudson, Union, Middlesex & Monmouth Counties (NJ)	Ozone (n-moderate)
	Fairfield & New Haven Counties (CT); Bronx, Kings, Nassau, New York, Queens, Richmond, Rockland, Suffolk, & Westchester Counties (NY); Bergen, Essex, Hudson, Union, Middlesex & Monmouth Counties (NJ)	1997 $PM_{2.5}$ (m) and 2006 $PM_{2.5}$ (m)
	New Haven County CT (p) New York County NY	PM_{10} (m) PM_{10} (n)
	Fairfield County CT (p)	CO (m)
Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE	Atlantic, Cape May & Ocean Counties	Ozone (n-marginal)
USEPA Region 3		
Seaford, DE	Sussex County	Ozone (n-marginal)
USEPA Region 4		
Nassau County, FL	Nassau County, FL (p)	2010 SO_2 (n)
Hillsborough County, FL	Hillsborough County, FL (p)	2010 SO_2 (n)
	Tampa, FL (p)	2008 Lead
USEPA Region 6		
Saint Bernard Par LA	Saint Bernard Parish, LA	2010 SO_2 (n)
Houston-Galveston-Brazoria, TX	Brazoria, Chambers, Galveston Counties, TX	Ozone (n-moderate)

Source: (U.S. Environmental Protection Agency, 2017b)
Notes: (p) means partial; (n) means nonattainment; (m) means maintenance
CO: carbon monoxide; PM_{10}: particulate matter ≤ 10 microns in diameter; $PM_{2.5}$: particulate matter ≤ 2.5 microns in diameter; SO_2: sulfur dioxide

The Greater Connecticut area is designated as moderate nonattainment for ozone. Table 3.1-4 lists Study Area pierside locations and the attainment status for each.

Table 3.1-4: Pierside and Coastal Activity Locations and Their Area's Attainment Status

Pierside Location	*Designated Area*	*National Ambient Air Quality Standards Attainment Status*
Portsmouth Naval Shipyard, Kittery Maine; Shipyard – Bath, Maine	Metropolitan Portland/ Cumberland County	Attainment of all applicable standards
Naval Undersea Warfare Center, Division, Newport, Newport, Rhode Island	Providence (all of RI), RI	Attainment of all applicable standards
Naval Submarine Base New London; Groton, Connecticut Shipyard – Groton, Connecticut and Thames River	Greater Connecticut, CT	Moderate nonattainment of the 8-hour ozone standard Attainment of all other applicable standards
Naval Station Norfolk, Norfolk, Virginia; Joint Expeditionary Base Little Creek-Fort Story, Virginia Beach, Virginia; Norfolk Naval Shipyard, Portsmouth, Virginia; Shipyard – Newport News, Virginia; Broad Bay; York River; James River and Tributaries	Hampton Roads Intrastate	Attainment of all applicable standards
Cooper River; Charleston Pier, South Carolina	Charleston County	Attainment of all applicable standards
Naval Submarine Base Kings Bay, Georgia	Camden County	Attainment of all applicable standards
Naval Station Mayport, Jacksonville, Florida; St. Johns River, Florida	Duval County	Attainment of all applicable standards
Port Canaveral, Cape Canaveral, Florida	Brevard County	Attainment of all applicable standards
Saint Andrew Bay, Florida	Bay County	Attainment of all applicable standards
Shipyard – Pascagoula, Mississippi	Jackson County	Attainment of all applicable standards

Source: 40 CFR part 81, Subpart C and Green Book Nonattainment and Maintenance Areas (U.S. Environmental Protection Agency, 2017b)

Figure 3.1-1 through Figure 3.1-4 show the nonattainment and maintenance areas that are within or adjacent to the AFTT Study Area.

3.1.2.3.1 Other Air Basins Adjacent to the Study Area

A substantial portion (over 70 percent) of all AFTT EIS/OEIS training and testing activities occur within the range complexes, which are adjacent to coastal attainment areas but located beyond state waters. The remaining 30 percent are largely conducted well offshore and a small percentage is performed in areas offshore of coastal nonattainment or maintenance areas. These areas include stretches of coastal areas of the northeast, areas adjacent to Nassau County, Florida, the Tampa area, the New Orleans area, and coastal areas around Houston. The migration of emissions from offshore sources to land is well-documented. In 1997, the International Maritime Organization adopted Annex VI, Regulations for the Prevention of Air Pollution from ships. These regulations were instituted for the commercial maritime industry due to recognition of the impact of vessel emissions, which can travel hundreds of miles, on coastal receptors and further inland. These emissions are particularly significant around the large ports on the coast of the United States, which include New York/New Jersey, Philadelphia, Baltimore, Norfolk, Charleston, Savannah, Jacksonville, Miami, South Louisiana, and Houston (U.S. Maritime Administration, 2016).

In addition to the Operational Areas (OPAREAs) and other areas further out to sea, there are also activities that occur within state waters. Vessels traverse state water during ingress/egress to OPAREAs and other Study Area locations further offshore. There are also training activities in particular that occur in coastal areas, including riverine and bay locations. The area of greatest activity is in the lower Chesapeake Bay and in tributaries to the bay, primarily the James and York Rivers in Virginia. Activities in Narragansett Bay are associated with the Naval Undersea Warfare Center Division, Newport in Rhode Island. Additional areas where training or testing occurs within state waters include the St. Johns River near Naval Station Mayport, Florida, Port Canaveral, Florida, St. Andrew Bay near Naval Support Activity Panama City, Florida and the Cooper River near Charleston, South Carolina. Of these, only Naval Station Mayport is located in an Air Quality Control Region with a nonattainment designation within its borders.

3.1.3 Environmental Consequences

This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives) potentially impact air quality within the Study Area. The air quality stressors vary in intensity, frequency, duration, and location within the Study Area. The stressor applicable to air quality in the Study Area is analyzed below:

- **Criteria Air Pollutants**

In this analysis, criteria air pollutant emissions estimates were calculated for vessels, aircraft, and munitions. For each alternative, emissions estimates were developed by range complex and other training or testing locations and totaled for the Study Area. Additionally, state waters emissions are separately analyzed for air quality impacts. Details of the emission estimates are provided in Appendix C (Air Quality Emissions Calculations and Record of Non-Applicability). Hazardous air pollutants are analyzed qualitatively in relation to the prevalence of the sources emitting hazardous air pollutants during training and testing activities.

Estimating Emissions of Criteria Air Pollutants

The potential impacts of criteria air pollutants are evaluated by first estimating the emissions from training and testing activities in the Study Area for each alternative. These estimates are then used to determine the potential impact of the emissions on the attainment status of the adjacent designated air quality area.

The estimate of criteria air pollutant emissions for each alternative is categorized by region (e.g., by range complex or testing range) so that differences in background air quality, atmospheric circulation patterns, regulatory requirements, and sensitive receptors can be addressed. An overall estimate of air pollutant emissions for Navy training and testing activities in the Study Area under each alternative is also provided. Under Alternative 1, emissions were based on the average number of training and testing activities anticipated, based on the prior 6 years of data. Under Alternative 2, emissions were based on the anticipated maximum number of training and testing activities. For vessel operations, the maximum was based on the operations that occurred in 2011 the year of the highest number of operations in the range 2010 – 2015. While this represented the year of most total operations, the number of operations involving specific vessels in the individual operational areas may or may not have been higher than the average number used in Alternative 1. These individual variances do not change the overall result of greater total operations when accounting for all vessels in all regions under Alternative 2.

Table 3.1-5 and Table 3.1-7 present the total emissions for the proposed training and testing activity locations under each alternative. Table 3.1-6 and Table 3.1-8 present the emissions specific to the Jacksonville nonattainment/maintenance area with a comparison to the General Conformity *de minimis* thresholds to assess the applicability of the General Conformity Regulations to the proposed action in this area.

The analysis below is organized by Alternative and provides both the NEPA impact analysis, and where appropriate, a separate discussion related to General Conformity requirements.

3.1.3.1 Impacts from Air Emissions Under Alternative 1

3.1.3.1.1 NEPA Impacts from Air Emissions under Alternative 1

Table 3.1-5 presents the total estimated emission results under Alternative 1 for each operational region in the Study Area and includes all emissions generated, regardless of proximity to the coastline. Most of these emissions occur beyond state waters. For Virginia Capes Range Complex, the use of vessels within the state waters is up to 2 percent, and in the Jacksonville Range Complex, the use of vessels within state waters is up to 1 percent.

The subsections that follow evaluate the emissions, both within the entire Study Area, and in state waters within the Study Area, under NEPA.

Table 3.1-5: Estimated Annual Air Pollutant Emissions from Activities Occurring within the AFTT Study Area, Alternative 1

Range Complex	*Emissions by Air Pollutant (TPY)*					
	VOC	*CO*	*NO_X*	*SO_X*	*PM_{10}*	*$PM_{2.5}$*
Northeast	6.0	25.0	143.4	28.3	9.7	9.7
Virginia Capes	121.9	939.8	3,722.7	984.1	190.7	190.7
Cherry Point	43.8	348.8	918.7	172.7	42.3	42.3
Jacksonville	49.4	485.7	1,069.8	306.6	71.5	71.5
Key West	2.8	12.2	76.7	12.9	5.4	5.4
Gulf of Mexico	8.3	122.3	416.5	108.6	25.2	25.2
Outside Range Complex Areas	53.7	332.8	1,683.1	383.5	55.5	55.5

Notes: CO: carbon monoxide; NO_x: oxides of nitrogen; VOC: volatile organic compounds; SO_x: sulfur oxides; PM_{10}: particulate matter less than or equal to 10 microns in diameter; $PM_{2.5}$: particulate matter less than or equal to 2.5 microns in aerodynamic diameter; TPY: tons per year.

A significant portion of the Study Area activities would occur well offshore. While pollutants emitted in the Study Area under Alternative 1 may at times be carried ashore by winds, most training and testing activities would occur more than 12 NM offshore, and natural mixing would substantially disperse pollutants before they reach the coastal land mass. The contributions of air pollutants generated in the Study Area to the air quality in onshore areas are unlikely to measurably add to existing onshore pollutant concentrations because of the distances these offshore pollutants would be transported and their substantial dispersion during transport.

3.1.3.1.2 General Conformity Analysis under Alternative 1 in Northeast Areas Designated Nonattainment or Maintenance

In the northeast, the primary areas where air pollution has resulted in designation of nonattainment or maintenance areas lie in the New York-Northern New Jersey-Long Island, NY-NJ-CT Air Quality Control Region (U.S. Environmental Protection Agency, 1972) (see Figure 3.1-1) which is moderate nonattainment for ozone, a maintenance area for particulate matter less than or equal to 2.5 microns in diameter, and includes a maintenance area for particulate matter less than or equal to 10 microns in diameter. A portion of the Eastern Connecticut Intrastate Control Region is also designated as moderate nonattainment for ozone. A very small area of coastal New Hampshire is nonattainment for sulfur dioxide, and there is a small area of ozone nonattainment in the coastal counties of New Jersey as well as near the coast at Seaford, Delaware. Activities in state waters are not scheduled to occur in any of these nonattainment or maintenance areas. The primary location where activities in state waters occur is at Naval Undersea Warfare Center Newport and Narragansett Bay, both of which are in Rhode Island, an area in attainment for all pollutants.

3.1.3.1.3 General Conformity Analysis under Alternative 1 in Jacksonville Florida Areas Designated Nonattainment or Maintenance

In the southeast, the area where air pollution has resulted in designation of a coastal nonattainment or maintenance area lies in Nassau County, Florida, which is just north of Jacksonville (see Figure 3.1-3). Both of these counties are in the Jacksonville (Florida)-Brunswick (Georgia) Interstate Air Quality Control Region. A portion of Nassau County is nonattainment for sulfur dioxide which will require that a General Conformity applicability analysis be performed to determine if a formal General Conformity Determination is required. Table 3.1-6 presents the estimated state waters emissions and their relevance to applicable General Conformity thresholds.

Table 3.1-6: Estimated Annual Air Pollutant Emissions from Activities Occurring in State Waters in the Jacksonville, Florida Area, Alternative 1

	Emissions by Air Pollutant (TPY)					
	VOC	*CO*	*NO_X*	*SO_X*	*PM_{10}*	*$PM_{2.5}$*
Nassau, FL SO_2 Nonattainment Area						
Total Emissions from all Sources	1.3	6.6	24.6	4.9	1.3	1.3
General Conformity Thresholds	NA	NA	NA	100	NA	NA
Exceedance?	NA	NA	NA	No	NA	NA

Notes: Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding.
CO: carbon monoxide; NO_X: nitrogen oxides; $PM_{2.5}$: particulate matter less than or equal to 2.5 microns in diameter; PM_{10}: particulate matter less than or equal to 10 microns in diameter; SO_X: sulfur oxides; TPY: tons per year; VOC: volatile organic compounds

Sulfur dioxide emissions in state waters associated with AFTT activities would be below the General Conformity *de minimis* thresholds. As a result, no further analysis of conformity is required and a Record of Non-Applicability, located in Appendix C, was prepared in accordance with Navy guidance.

3.1.3.1.4 General Conformity Analysis under Alternative 1 in the Gulf of Mexico Areas Designated Nonattainment or Maintenance

In the Gulf of Mexico, the primary areas where air pollution has resulted in designation of nonattainment or maintenance areas lie in Hillsborough County, Florida (see Figure 3.1-1) which is nonattainment for sulfur dioxide and lead; Saint Bernard Parish, Louisiana, which is also nonattainment for sulfur dioxide; and the Houston-Galveston-Brazoria ozone nonattainment area. Activities in state waters are not scheduled to occur in any of these nonattainment or maintenance areas. The primary location where state water activities in this region do occur is at Naval Surface Warfare Center Panama City Division, Florida which is in attainment for all pollutants.

3.1.3.1.5 Summary of Impacts from Criteria Pollutants under Alternative 1

While both criteria and hazardous air pollutants emitted in the Study Area under Alternative 1 may at times be carried ashore by prevailing winds, most training and testing activities would occur beyond state water boundaries and natural mixing would substantially disperse pollutants before they reach the boundaries of the adjacent air quality control regions. Additionally, the primary wind pattern moves from shore to offshore (National Aeronautics and Space Administration, 2018). The contributions of air pollutants generated in the Study Area to the air quality in the air quality control regions are unlikely to measurably add to existing onshore pollutant concentrations because of the distances these offshore pollutants would be transported, their substantial dispersion during transport and the intermittent short-term nature of the activities. Therefore, no significant impacts on air quality as a result of criteria pollutants over state waters would occur; and no significant harm to air quality as a result of criteria pollutant emissions beyond state waters would occur. Total direct and indirect emissions of criteria pollutants under Alternative 1 also fall below de minimis levels, thus a General Conformity Analysis is not required.

3.1.3.2 Impacts from Air Emissions under Alternative 2

3.1.3.2.1 NEPA Impacts from Air Emissions under Alternative 2

Table 3.1-7 presents the total estimated emission results under Alternative 2 for each operational region in the Study Area and includes all emissions generated, regardless of proximity to the coastline. Most of these emissions occur beyond state waters. For Virginia Capes Range Complex, the use of vessels within the state waters is greater than in other portions of the Study Area.

The subsections that follow evaluate the state waters emissions within the regional areas that include nonattainment or maintenance areas. These emissions are compared to the General Conformity *de minimis* thresholds, and are not specific to specific localities. This conservative approach, then, evaluates all nearshore emissions as potentially occurring in any of the applicable nonattainment or maintenance areas.

Table 3.1-7: Estimated Annual Air Pollutant Emissions from Activities Occurring within the AFTT Study Area, Alternative 2

	Emissions by Air Pollutant (TPY)					
	VOC	*CO*	*NO_X*	*SO_X*	*PM_{10}*	*$PM_{2.5}$*
Northeast	5.5	26.3	120.8	20.3	12.1	12.1
Virginia Capes	118.0	935.9	3,993.9	1,070.8	211.6	211.6
Cherry Point	33.1	185.9	821.5	194.7	39.9	39.9
Jacksonville	61.2	602.8	1,994.2	540.3	88.9	88.9
Key West	0.9	14.3	30.3	10.6	3.7	3.7
Gulf of Mexico	1.7	27.4	59.7	19.7	9.7	9.7
Outside Range Complex Areas	162.4	569.7	4,160.7	656.8	90.2	90.2

Notes: CO: carbon monoxide; NO_x: oxides of nitrogen; VOC: volatile organic compounds; SO_x: sulfur oxides; PM_{10}: particulate matter less than or equal to 10 microns in diameter; $PM_{2.5}$: particulate matter less than or equal to 2.5 microns in diameter; TPY: tons per year.

A significant portion of the Study Area activities would occur well offshore. While pollutants emitted in the Study Area under Alternative 2 may at times be carried ashore by winds, most training and testing activities would occur more than 12 NM offshore, and natural mixing would substantially disperse pollutants before they reach the coastal land mass. The contributions of air pollutants generated in the Study Area to the air quality in onshore areas are unlikely to measurably add to existing onshore pollutant concentrations because of the distances these offshore pollutants would be transported and their substantial dispersion during transport.

3.1.3.2.2 General Conformity Analysis under Alternative 2 in Northeast Areas Designated Nonattainment or Maintenance

In the northeast, the primary areas where air pollution has resulted in designation of nonattainment or maintenance areas lies in the New York-Northern New Jersey-Long Island, NY-NJ-CT Air Quality Control Region (U.S. Environmental Protection Agency, 1972) (see Figure 3.1-1) which is moderate nonattainment for ozone, a maintenance area for particulate matter less than or equal to 2.5 microns in diameter, and includes a maintenance area for particulate matter less than or equal to 10 microns in diameter. A portion of the Eastern Connecticut Intrastate Control Region is also designated as moderate nonattainment for ozone. A very small area of coastal New Hampshire is nonattainment for sulfur dioxide, and there is a small area of ozone nonattainment near the coast at Seaford, Delaware. State waters activities are not scheduled to occur in any of these nonattainment or maintenance areas. The primary location where state waters activities in this region do occur is at Naval Undersea Warfare Center Division Newport and Narragansett Bay, both of which are in Rhode Island, an area in attainment for all pollutants.

3.1.3.2.3 General Conformity Analysis under Alternative 2 in Jacksonville Florida Areas Designated Nonattainment or Maintenance

In the southeast, the area where air pollution has resulted in designation of a coastal nonattainment or maintenance area lies in the Nassau County, Florida, which is just north of Jacksonville (see Figure 3.1-3). Both of these counties are in the Jacksonville (Florida)-Brunswick (Georgia) Interstate Air Quality Control Region. A portion of this county is nonattainment for sulfur dioxide. Table 3.1-8 presents the estimated nearshore emissions and their relevance to applicable General Conformity thresholds.

Table 3.1-8: Estimated Annual Air Pollutant Emissions from Activities Occurring within 3 NM of shore in the Jacksonville, Florida Area, Alternative 2

	Emissions by Air Pollutant (TPY)					
	VOC	*CO*	*NO_X*	*SO_X*	*PM_{10}*	*$PM_{2.5}$*
Nassau, FL SO_2 Nonattainment Area						
Total Emissions from all Sources	1.5	9.6	30.7	6.1	1.6	1.6
General Conformity Thresholds	NA	NA	NA	100	NA	NA
Exceedance?	NA	NA	NA	No	NA	NA

Notes: Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding.
CO: carbon monoxide; NO_X: nitrogen oxides; $PM_{2.5}$: particulate matter less than or equal to 2.5 microns in diameter; PM_{10}: particulate matter less than or equal to 10 microns in diameter; SO_X: sulfur oxides; TPY: tons per year; VOC: volatile organic compounds

Sulfur dioxide emissions in state waters that are associated with AFTT activities would be below the General Conformity *de minimis* thresholds. As a result, no further analysis of conformity is required and a Record of Non-Applicability, located in Appendix C, was prepared in accordance with Navy guidance.

3.1.3.2.4 General Conformity Analysis under Alternative 2 in the Gulf of Mexico Adjacent Areas Designated Nonattainment or Maintenance

In the Gulf of Mexico, the primary areas where air pollution has resulted in designation of nonattainment or maintenance areas lie in Hillsborough County, Florida (see Figure 3.1-1) which is nonattainment for sulfur dioxide and lead; Saint Bernard Parish, Louisiana, which is also nonattainment for sulfur dioxide; and the Houston-Galveston-Brazoria ozone nonattainment area. State waters activities are not scheduled to occur in any of these nonattainment or maintenance areas. The primary location where state waters activities in this region do occur is at Naval Surface Warfare Center Panama City Division, Florida which is in attainment for all pollutants. As a result, the General Conformity Regulations do not apply.

3.1.3.2.5 Summary of Impacts from Criteria Pollutants under Alternative 2

While pollutants emitted in the Study Area under Alternative 2 may at times be carried ashore by prevailing winds, most training and testing activities would occur more than 3 NM offshore, and natural mixing would substantially disperse pollutants before they reach the boundaries of the adjacent air quality control regions. The contributions of air pollutants generated in the Study Area to the air quality in the air quality control regions are unlikely to measurably add to existing onshore pollutant concentrations because of the distances these offshore pollutants would be transported and their substantial dispersion during transport. Total direct and indirect emissions of criteria pollutants under Alternative 1 also fall below de minimis levels, thus a General Conformity Analysis is not required.

3.1.3.3 Impacts from Air Pollutants under the No Action Alternative

Under the No Action Alternative, training and testing activities associated with the Proposed Action would not be conducted within the AFTT Study Area. Discontinuing training and testing activities in the Study Area under the No Action Alternative would not measurably improve air quality in the Study Area because of the discontinuous nature of the events that constitute the Proposed Action and the fact that most of the air emissions that are generated occur at sea over a wide geographic area. The elimination of the air emissions associated with training activities in the lower Chesapeake Bay and its tributaries may be beneficial to local air quality in this region because it is the area of highest activity in state waters. It should be noted that the air quality in this area already surpasses the National Ambient Air Quality Standards.

3.1.3.4 Greenhouse Gases and Climate Change

Activities conducted as part of the Proposed Action would involve mobile sources using fossil fuel combustion as a source of power. Additionally, the expenditure of munitions could generate greenhouse gas emissions. While the emissions generated by testing and training activities alone would not be enough to cause global warming, in combination with past and future emissions from all other sources they would contribute incrementally to the global warming that produces the adverse effects of climate change.

Greenhouse gas emissions for all of the training and testing activities occurring annually throughout the entire Study Area were calculated using emissions factors provided by the U.S. Navy for aircraft and vessels, and published by the USEPA for munitions. The analysis of greenhouse gas emissions associated with aircraft is limited to those emissions below 3,000 ft. because there is insufficient historical data to document the entire flight path or flight duration of any given aircraft for a specific training or testing event. This is also true for the baseline data so that the totals for the baseline, Alternative 1 and Alternative 2 are comparable. A comparative analysis was performed using the greenhouse gas emission estimates prepared for the Preferred Alternative in the 2013 AFTT Final EIS/OEIS. A net decrease in greenhouse gas emissions would be anticipated compared to the 2013 estimates, with the largest decrease associated with Alternative 1, as indicated in Table 3.1-9.

Table 3.1-9: Total Annual Greenhouse Gas Emissions from All Study Area Training and Testing Activities in Metric Tons per Year

2013 Emission Estimates	*Alternative 1 Emissions*	*Net Change from 2013 Estimates*	*Alternative 2 Emissions*	*Net Change from 2013 Estimates*
1,360,794	1,027,261	-333,533	1,235,075	-125,719

3.1.4 Summary of Potential Impacts on Air Quality

In this analysis, criteria air pollutant and greenhouse gas emissions estimates were calculated for vessels, aircraft, and munitions. For each alternative, emissions estimates were developed by range complex and other training or testing locations and totaled for the Study Area. Details of the emission estimates are provided in Appendix C (Air Quality Emissions Calculations and Example Record of Non-Applicability).

3.1.4.1 Combined Impacts of All Stressors under Alternative 1

Emissions associated with Study Area training and testing activities under Alternative 1 primarily occur beyond the boundary for state waters. For fixed-wing aircraft activities, emissions typically occur above the 3,000 ft. mixing layer. Given these characteristics, the impact on air quality from the combination of these resource stressors are expected to be similar to the impacts on air quality for any of these stressors taken individually without any additive synergistic, or antagonistic interaction. To provide a general comparative analysis, the emissions data for each alternative were compared to the emission data from the Preferred Alternative selected in the 2013 AFTT Final EIS/OEIS. A comparison of estimated emissions under Alternative 1 to the 2013 Preferred Alternative (which was subsequently adopted) indicates that some pollutant emissions would be reduced and others would increase. Emissions of volatile organic compounds, carbon monoxide, and greenhouse gases would decrease. Nitrogen oxides, sulfur dioxide and particulate matter would increase. A significant cause of the increase in nitrogen oxide, particulate matter, and sulfur dioxide emissions is due to the inclusion of riverine and bay testing and training activities, particularly in the Virginia environs. These activities were not analyzed as part of the air quality analysis in the 2013 document.

3.1.4.2 Combined Impacts of All Stressors under Alternative 2

Emissions associated with Study Area training and testing activities under Alternative 2 primarily occur beyond the boundary for state waters. For fixed-wing aircraft activities, emissions typically occur above the 3,000 ft. mixing layer. Given these characteristics, the impact on air quality from the combination of these resource stressors are expected to be similar to the impacts on air quality for any of these stressors taken individually without any additive synergistic, or antagonistic interaction. A comparison of estimated emissions under Alternative 2 in comparison to the baseline indicates that some pollutants emissions would be reduced and others would increase. Emissions of volatile organic compounds, carbon monoxide, and greenhouse gases would decrease. Nitrogen oxides, particulate matter, and sulfur dioxide would increase. A significant cause of the increase in nitrogen oxide and sulfur dioxide emissions is due to the inclusion riverine and bay testing and training activities, particularly in the Virginia environs. These activities were not accounted for in the analyses presented in the phase 2013 AFTT Final EIS/OEIS Proposed Action.

3.1.4.3 Combined Impacts of All Stressors under the No Action Alternative

Training and testing activities associated with the Proposed Action would not be conducted within the AFTT Study Area.

Discontinuing training and testing activities in the Study Area under the No Action Alternative would not measurably improve air quality in the Study Area because of the discontinuous nature of the events that constitute the Proposed Action and the fact that most of the air emissions that are generated occur at sea over a wide geographic area. The elimination of the air emissions associated with training activities in the lower Chesapeake Bay and its tributaries may be beneficial to local air quality in this region because it is the area of highest activity in state waters. It should be noted that the air quality in this area is already better than the National Ambient Air Quality Standards.

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

TABLE OF CONTENTS

List of Figures

List of Tables

3.2 Sediments and Water Quality

SEDIMENTS AND WATER QUALILTY SYNOPSIS

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

- <u>Explosives and explosives byproducts</u>: Impacts from explosives and explosives byproducts would be short term and local. Impacts from unconsumed explosives and constituent chemical compounds would be minimal and limited to the area adjacent to the munition. Explosives and constituent compounds could persist in the environment depending on the integrity of the undetonated munitions casing and the physical conditions on the seafloor where the munition resides. Chemical and physical changes to sediments and water quality, as measured by the concentrations of contaminants or other anthropogenic compounds, may be detectable and would be below applicable regulatory standards for determining effects on biological resources and habitats.
- <u>Chemicals other than explosives</u>: Impacts from other chemicals not associated with explosives would be both short term and long term depending on the chemical and the physical conditions on the seafloor where the source of the chemicals resides. Impacts would be minimal and localized to the immediate area surrounding the source of the chemical release.
- <u>Metals</u>: Impacts from metals would be minimal and long term and dependent on the metal and the physical conditions on the seafloor where the metal object (e.g., non-explosive munition) resides. Impacts would be localized to the area adjacent to the metal object. Concentrations of metal contaminants near the expended material or munition may be measurable and are likely to be similar to the concentrations of metals in sediments from nearby reference locations.
- <u>Other materials</u>: Impacts from other expended materials not associated with munitions would be both short term and long term depending on the material and the physical conditions (e.g., substrate, temperature, currents) on the seafloor where the material resides. Impacts would be localized to the immediate area surrounding the material. Chemical and physical changes to sediments and water quality, as measured by the concentrations of contaminants or other anthropogenic compounds near the expended material, are not likely to be detectable and would be similar to the concentrations of chemicals and material residue from nearby reference locations.

3.2.1 Introduction and Methods

3.2.1.1 Introduction

The following sections provide an overview of the characteristics of sediments and water quality in the Atlantic Fleet Training and Testing (AFTT) Study Area (Study Area), and describe, in general terms, the methods used to analyze potential impacts of the Proposed Action on these resources.

3.2.1.1.1 Sediments

The discussion of sediments begins with an overview of sediment sources and characteristics in the Study Area, and considers factors that have the potential to affect sediment quality.

3.2.1.1.1.1 Characteristics of Sediments

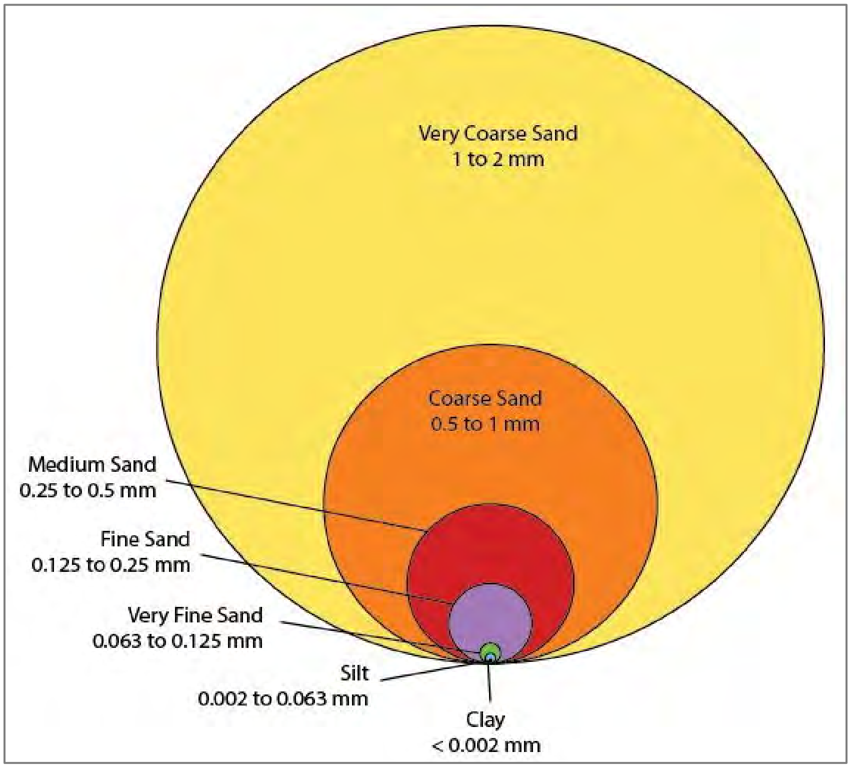


Figure 3.2-1: Sediment Particle Size Comparison

Sediments consist of solid fragments of organic and inorganic matter forming the bottom, or substrate, of bodies of water. Sediments in the marine environment (e.g., in ocean basins) are either terrigenous, meaning that they originate from land, or are biogenic (i.e., formed from the remains of marine organisms). Terrigenous sediments come from the weathering of rock and other land-based substrates and are transported by water, wind, and ice (glaciers) to the seafloor. Biogenic sediments are produced in the oceans by the skeletal remains of single-celled benthic and planktonic organisms (e.g., foraminiferans and diatoms). When an organism dies, its remains are deposited on the seafloor. The remains are composed primarily of either calcium carbonate (e.g., a shell) or silica, and mixed with clays, form either a calcareous or siliceous ooze (Chester, 2003). Sediments in the Atlantic Ocean are predominantly composed of calcareous oozes, and the Pacific Ocean has more siliceous oozes (Kennett, 1982). In addition to composition, sediments are also classified by size. Blott and Pye (2012) reviewed commonly used historical classification systems and offered a refined system that is adopted for describing sediments in this section. Sediments are grouped into five size classes: boulders, gravel, sand, silt, and clay. Sands range in size from 0.063 millimeter (mm) (very fine sands) to 2 mm (very coarse sands) (Figure 3.2-1). For comparison, the thickness of a nickel is approximately 2 mm. Sediment types smaller than sands are silts (0.002 to 0.063 mm in diameter) and clays (particles less than 0.002 mm in diameter). Sediments larger than sands are various types of gravel ranging in size from 2 mm (granules) to 64 mm (cobbles). Sediments greater than 64 mm in diameter are defined as boulders and range up to 2,048 mm (Blott & Pye, 2012; U.S. Department of Agriculture, 1993). Fine-grained silts and clays are often found mixed together in areas beyond the continental slope, such as on abyssal plains, and are referred to generally as mud (Kennett, 1982). Sediments in nearshore waters and on the continental shelf contain more sands that are primarily terrigenous, and sediments farther from shore in deep ocean basins are primarily biogenic. As organic and inorganic particles move downward through the water column and ultimately to the seafloor, many substances, including contaminants, that adhere to the particles and are otherwise scarce in the water column, become concentrated in bottom sediments (Chapman et al., 2003; Kszos et al., 2003).

3.2.1.1.1.2 Factors Affecting Marine Sediment Quality

The quality of sediments is influenced by their physical, chemical, and biological components; by where they are deposited; by the properties of seawater; and by other inputs and sources of contamination. Sediments tend to be dynamic, where factors affecting marine sediments often interact and influence each other. These factors are summarized below.

Physical characteristics and processes: At any given site, the texture and composition of sediments are important physical factors that influence the types of substances that are retained in the sediments, and subsequent biological and chemical processes. For example, clay-sized and smaller sediments and similarly sized organic particles tend to bind potential sediment contaminants and potentially limit their movement in the environment (U.S. Environmental Protection Agency, 2009). Conversely, fine-grained sediments are easily disturbed by currents and bottom-dwelling organisms, dredging, storms, and bottom trawling (Eggleton & Thomas, 2004; Hedges & Oades, 1997). Disturbance is also possible in deeper areas, where currents are minimal (Carmody et al., 1973), from mass wasting events such as underwater slides and debris flows (Coleman & Prior, 1988). If re-suspended, fine-grained sediments (and any substances bound to them) can be transported long distances.

Chemical characteristics and processes: The concentration of oxygen in sediments strongly influences sediment quality through its effect on the binding of materials to sediment particles. At the sediment surface, the level of oxygen is usually the same as that of the overlying water. Deeper sediment layers, however, are often low in oxygen (i.e., hypoxic) or have no oxygen (i.e., anoxic), and have a low oxidation-reduction potential, which predicts the stability of various compounds that regulate nutrient and metal availability in sediments. Certain substances combine in oxygen-rich environments and become less available for other chemical or biological reactions.

Biological characteristics and processes: Organic matter in sediments provides food for resident microbes. The metabolism of these microbes can change the chemical environment in sediments and thereby increase or decrease the mobility of various substances and influence the ability of sediments to retain and transform those substances (Mitsch et al., 2009; U.S. Environmental Protection Agency, 2008c). Bottom-dwelling animals often rework sediments in the process of feeding or burrowing. In this way, marine organisms influence the structure, texture, and composition of sediments, as well as, the horizontal and vertical distribution of substances in the sediment (Boudreau, 1998). Moving substances out of or into low or no-oxygen zones in the sediment may alter the form and availability of various substances. The metabolic processes of bacteria also influence sediment components directly. For example, sediment microbes may convert mercury to methyl mercury, increasing its toxicity (Mitchell & Gilmour, 2008). However, it is more common that biological processes breakdown contaminants and reduce toxicity in sediments (White et al., 1997).

Location: The quality of coastal and marine sediments is influenced substantially by inputs from adjacent watersheds (Turner & Rabalais, 2003). Proximity to watersheds with large cities or intensively farmed lands often increases the amount of both inorganic and organic contaminants that find their way into coastal and marine sediments. A wide variety of metals and organic substances, such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and pesticides—often referred to collectively as "persistent organic pollutants"—are discharged into coastal waters by urban, agricultural, and industrial point and non-point sources in the watershed (U.S. Environmental Protection Agency, 2008c). Location on the ocean floor also influences the distribution and concentration of various elements through local geology and volcanic activity (Demina & Galkin, 2009), as well as through landslides and debris flow events (Coleman & Prior, 1988).

Other Contributions to Sediments: While the greatest mass of sediments is carried into marine systems by rivers (U.S. Environmental Protection Agency, 2008c), wind and rain also deposit materials in coastal waters and contribute to the mass and quality of sediments. For example, approximately 80 percent of the mercury released by human activities comes from coal combustion, mining and smelting, and solid waste incineration (Agency for Toxic Substances and Disease Registry, 1999). These activities are generally considered to be the major sources of mercury in marine systems (Fitzgerald et al., 2007). Atmospheric deposition of lead is similar in that human activity is a major source of lead in sediments (Wu & Boyle, 1997).

3.2.1.1.2 Water Quality

The discussion of water quality begins with an overview of the characteristics of marine waters, including pH (a measure of acidity), temperature, oxygen, nutrients, salinity, and dissolved elements. The discussion then considers how those characteristics of marine waters are influenced by physical, chemical, and biological processes.

3.2.1.1.2.1 Characteristics of Marine Waters

The composition of water in the marine environment is determined by complex interactions among physical, chemical, and biological processes. Physical processes include region-wide currents and tidal flows, seasonal weather patterns and temperature, sediment characteristics, and unique local conditions, such as the volume of fresh water delivered by large rivers. Chemical processes involve salinity, pH, dissolved minerals and gases, particulates, nutrients, and pollutants. Biological processes involve the influence of living things on the physical and chemical environment. The two dominant biological processes in the ocean are photosynthesis and respiration, particularly by microorganisms. These processes involve the uptake, conversion, and excretion of waste products during growth, reproduction, and decomposition (Mann & Lazier, 1996).

3.2.1.1.2.2 Influences of Marine Properties and Processes on Seawater Characteristics

Ocean currents and tides mix and redistribute seawater. In doing so, they alter surface water temperatures, transport and deposit sediment, and concentrate and dilute substances that are dissolved and suspended in the water. These processes operate to varying degrees from nearshore areas to the abyssal plain. Salinity also affects the density of seawater and, therefore, its movement relative to the sea surface (Libes, 2009). Upwelling brings cold, nutrient-rich waters from deeper areas, increasing the productivity of local surface waters (Mann & Lazier, 1996). Storms and hurricanes also cause strong mixing of marine waters (Li et al., 2008).

Temperature and pH influence the behavior of trace metals in seawater, such as the extent to which they dissolve in water (i.e., the metal’s solubility) or their tendency to adsorb organic and inorganic particles. However, the degree of influence differs widely among metals (Byrne, 1996). The concentration of a given element may change with position in the water column. For example, some metals (e.g., cadmium) are present at low concentrations in surface waters and at higher concentrations at depth (Bruland, 1992), while others decline quickly with increasing depth below the surface (e.g., zinc and iron) (Nozaki, 1997). On the other hand, dissolved aluminum concentrations are highest at the surface, lowest at mid-depths, and increase again at depths below about 1,000 meters (Li et al., 2008).

Substances, such as nitrogen, carbon, silicon, and trace metals, are extracted from the water by biological processes. Others, like oxygen and carbon dioxide, are produced by biological processes. Metabolic waste products add organic compounds to the water, and may also absorb trace metals, removing those metals from the water column. Those organic compounds may then be consumed by biological organisms, or they may aggregate with other particles and sink (Mann & Lazier, 1996; Wallace et al., 1977).

Runoff from coastal watersheds influences local and regional coastal water conditions, especially large rivers. Influences include increased sediments and pollutants, and decreased salinity (Rabalais et al., 2002; Turner & Rabalais, 2003; Wiseman & Garvine, 1995). Coastal bays and large estuaries serve to filter river outflows and reduce total discharge of runoff to the ocean (Edwards et al., 2006; Mitsch et al., 2009). Depending on their structure and components, estuaries can directly or indirectly affect coastal water quality by recycling various compounds (e.g., excess nutrients), sequestering elements in more inert forms (e.g., trace metals), or altering them, such as the conversion of mercury to methyl mercury (Mitchell & Gilmour, 2008; Mitsch & Gosselink, 2007).

3.2.1.1.2.3 Coastal Water Quality

Most water quality problems in coastal waters of the United States are from degraded water clarity or increased concentrations of phosphates or chlorophyll-*a* (U.S. Environmental Protection Agency, 2012b). Water quality indicators measured are dissolved inorganic nitrogen, dissolved inorganic phosphorus, water clarity or turbidity, dissolved oxygen, and chlorophyll-*a*. Chlorophyll-*a* is an indicator of microscopic algae (phytoplankton) abundance used to judge nutrient availability (e.g., phosphates and nitrates). Excess phytoplankton blooms can decrease water clarity and, when phytoplankton die off following blooms, lower concentrations of dissolved oxygen. Most sources of these impacts arise from on-shore point and non-point sources of pollution. Point sources are direct water discharges from a single source, such as industrial or sewage treatment plants, while non-point sources are the result of many diffuse sources, such as runoff caused by rainfall.

3.2.1.2 Methods

The following four stressors may impact sediments or water quality: (1) explosives and explosives byproducts, (2) metals, (3) chemicals other than explosives, and (4) a miscellaneous category of other materials (e.g., plastics). The term “stressor” is used because the military expended materials in these four categories may affect sediments or water quality by altering their physical or chemical characteristics. The potential impacts of these stressors are evaluated based on the extent to which the release of these materials could directly or indirectly impact sediments or water quality such that existing laws or standards would be violated or recommended guidelines would be exceeded. The differences between standards and guidelines are described below.

- **Standards** are established by law or through government regulations that have the force of law. Standards may be numerical or narrative. Numerical standards set allowable concentrations of specific pollutants (e.g., micrograms per liter [µg/L]) or levels of other parameters (e.g., pH) to protect the water’s designated uses. Narrative standards describe water conditions that are not acceptable.
- **Guidelines** are non-regulatory, and generally do not have the force of law. They reflect an agency’s preference or suggest conditions that should prevail. Guidelines are often used to assess the condition of a resource to guide subsequent steps, such as the disposal of dredged materials. Terms such as screening criteria, effect levels, and recommendations are also used.

3.2.1.2.1 State Standards and Guidelines

State jurisdiction regarding sediments and water quality extends from the low tide line to 3 nautical miles (NM) offshore for all states except Texas and the Gulf coast of Florida where state waters extend to 9 NM offshore. Waters under the jurisdiction of Puerto Rico also extend to 9 NM, and waters under the control of the United States (U.S.) Virgin Islands extend to 3 NM offshore. Creating state-level sediments and water quality standards and guidelines begins with each state establishing a use for the water, which is referred to as its “designated” use. Examples of such uses of marine waters include fishing, shellfish harvesting, and recreation. For this section, a water body is considered “impaired” if any one of its designated uses is not met. Once this use is designated, standards or guidelines are established to protect the water at the desired level of quality. Applicable state standards and guidelines specific to each stressor are detailed in Section 3.2.3 (Environmental Consequences).

3.2.1.2.2 Federal Standards and Guidelines

Federal jurisdiction regarding sediments and water quality extends from 3 to 200 NM along the Atlantic and Gulf coasts of the United States. However, as discussed in the prior paragraph, for Texas, Puerto Rico, and Florida’s Gulf coast, federal jurisdiction begins at 9 NM from shore and extends seaward to 200 NM. These standards and guidelines are mainly the responsibility of the U.S. Environmental Protection Agency (USEPA), specifically ocean discharge provisions of the Clean Water Act (33 United States Code [U.S.C.] section 1343). Ocean discharges may not result in “unreasonable degradation of the marine environment.” Specifically, disposal may not result in: (1) unacceptable negative effects on human health; (2) unacceptable negative effects on the marine ecosystem; (3) unacceptable negative persistent or permanent effects due to the particular volumes or concentrations of the dumped materials; and (4) unacceptable negative effects on the ocean for other uses as a result of direct environmental impact (40 Code of Federal Regulations [CFR] section 125.122). Applicable federal standards and guidelines specific to each stressor are detailed in Section 3.2.3 (Environmental Consequences). Proposed training and testing activities also occur beyond 200 NM. Even though Clean Water Act regulations may not apply, pertinent water quality standards are used as accepted scientific standards to assess potential impacts on sediments and water quality from the Proposed Action.

The International Convention for the Prevention of Pollution from Ships (Convention) addresses pollution generated by normal vessel operations. The Convention is incorporated into U.S. law as 33 U.S.C. sections 1901–1915. The Convention includes six annexes: Annex I, oil discharge; Annex II, hazardous liquid control; Annex III, hazardous material transport; Annex IV, sewage discharge; Annex V, plastic and garbage disposal; and Annex VI, air pollution. The Navy is required to comply with the Convention; however, the United States is not a party to Annex IV. The discharge of sewage by military vessels is regulated by Section 312(d) of the Clean Water Act. The Convention contains handling requirements and specifies where materials can be discharged at sea, but it does not contain standards related to sediments nor water quality.

The National Defense Authorization Act of 1996 amended Section 312 of the Clean Water Act, directing the USEPA and the Department of Defense to jointly establish the Uniform National Discharge Standards for discharges (other than sewage) incidental to the normal operation of military vessels. The Uniform National Discharge Standards program establishes national discharge standards for military vessels in U.S. coastal and inland waters extending seaward to 12 NM. Twenty-five types of discharges were identified as requiring some form of pollution control (e.g., a device or policy) to reduce or eliminate the potential for impacts. The discharges addressed in the program include, ballast water, deck runoff, and seawater used for cooling equipment. For a complete list of discharges refer to 40 CFR part 1700.4.

These national discharge standards reduce the environmental impacts associated with vessel discharges, stimulate the development of improved pollution control devices aboard vessels, and advance the development of environmentally sound military vessels. The U.S. Navy adheres to regulations outlined in the Uniform National Discharge Standards program, and, as such, the analysis of impacts in this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) will be limited to potential impacts from training and testing activities including impacts from military expended materials, but not impacts from discharges addressed under the Convention or the Uniform National Discharge Standards program.

3.2.1.2.3 Intensity and Duration of Impact

The intensity or severity of impact is defined as follows (listed by increasing level of impact):

- Chemical, physical, or biological changes in sediment or water quality would not be detectable as a result of the use of military materials. The proposed activities would not violate water quality standards.
- Chemical, physical, or biological changes in sediment or water quality would be measurable, but total concentrations would not violate applicable standards, regulations, and guidelines. Sediment or water quality would be equivalent to existing conditions, and designated uses of the water body or substrate would not change.
- Chemical, physical, or biological changes in sediment or water quality would be measurable and readily apparent, but total concentrations would not violate applicable standards, regulations, and guidelines. Sediment or water quality would be altered compared to the historical baseline or desired conditions, and designated uses of the water body or substrate would be changed. Mitigation would be necessary and would likely be successful.
- Chemical, physical, or biological changes in sediment or water quality would be readily measurable, and some standards, regulations, and guidelines would be periodically approached, equaled, or exceeded as measured by total concentrations. Sediment or water quality would be frequently altered from the historical baseline or desired conditions, and designated uses of the water body or substrate would be changed. Mitigation measures would be necessary to limit or reduce impacts on sediment or water quality, although the efficacy of those measures would not be assured.

Duration is characterized as either short term or long term. Short-term is defined as days or months. Long-term is defined as months or years, depending on the type of activity or the materials involved.

3.2.1.2.4 Measurement and Prediction

Many of the conditions discussed above often influence each other, so measuring and characterizing various substances in the marine environment is often difficult (Byrne, 1996; Ho et al., 2007). For instance, sediment contaminants may also change over time. Valette-Silver (1993) reviewed several studies that demonstrated the gradual increase in a variety of contaminants in coastal sediments that began as early as the 1800s, continued into the 1900s, peaked between the 1940s and 1970s, and declined thereafter (e.g., lead, dioxin, polychlorinated biphenyls). After their initial deposition, normal physical, chemical, and biological processes can re-suspend, transport, and redeposit sediments and associated substances in areas far removed from the source (Hameedi et al., 2002; U.S. Environmental Protection Agency, 2012b). The conditions noted above further complicate predictions of the impact of various substances on the marine environment.

3.2.1.2.5 Sources of Information

Relevant literature was systematically reviewed to complete this analysis of sediments and water quality. The review included journals, technical reports published by government agencies, work conducted by private businesses and consulting firms, U.S. Department of Defense reports, operational manuals, natural resource management plans, and current and prior environmental documents for facilities and activities in the Study Area.

Because of the proximity of inshore and nearshore areas to humans, information on the condition of sediments and water quality in those areas tends to be relatively readily available. However, much less is known about deep ocean sediments and open ocean water quality. Since sediments and water quality in inshore and nearshore areas tends to be affected by various human social and economic activities, two general assumptions are used in this discussion: (1) sediments and water quality generally improve as distance from shore increases; and (2) sediments and water quality generally improve as depth increases.

3.2.1.2.6 Areas of Analysis

The locations where specific military expended materials would be used are discussed under each stressor in Section 3.2.3 (Environmental Consequences).

3.2.2 Affected Environment

The affected environment includes sediments and water quality within the Study Area, from nearshore areas to the open-ocean and deep sea bottom. Existing sediment conditions are discussed first and water quality conditions thereafter.

3.2.2.1 Sediments

The following subsections discuss sediments for each region in the Study Area. Note that sand and gravel harvested from offshore along the U.S. Atlantic coast and in the Gulf of Mexico are discussed as a socioeconomic resource in Section 3.11 (Socioeconomic Resources). Impacts on sediments discussed in Section 3.2.3 (Environmental Consequences) are also relevant to sand and gravel, but Section 3.11 (Socioeconomic Resources) analyzes the use of sand and gravel as a resource for purposes such as beach replenishment.

3.2.2.1.1 Sediment Descriptions in Geographic Regions of the Study Area

3.2.2.1.1.1 Sediments in the North Atlantic Region

The North Atlantic region consists of the West Greenland Shelf, the Newfoundland-Labrador Shelf, and the Scotian Shelf Large Marine Ecosystems, as well as the Labrador Current Open Ocean Area (see Figure 3.0-1 in Section 3.0, Introduction). The region includes the coasts and offshore marine areas southwest of Greenland, east and northeast of Newfoundland and Labrador, and surrounding Nova Scotia. Substrate in the North Atlantic region is comprised almost entirely of soft, unconsolidated sediments derived from terrestrial erosion of sedimentary rock. The most common types of sedimentary rock are sandstone and shale. The majority of sediments on the continental shelf were deposited by receding glaciers and weathered terrestrial rock (Kennett, 1982). Within the region, deposits of larger grain-sized gravel are found in the Gulf of Maine, whereas smaller grain-sized, quartz-rich sands dominate the remainder of the northeastern continental shelf (Churchill, 1989). Sediments in the North Atlantic region contain very little carbonate (less than 5 percent) (Chang et al., 2001; Kennett, 1982).

Although there are no designated range complexes in this region, the area may be used for Navy training and testing activities. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within each large marine ecosystem.

Low population densities and low levels of coastal development in the North Atlantic region, limit the amount of pollution from land-based sources in the North Atlantic region (Aquarone & Adams, 2009a, 2009b; Aquarone et al., 2009). However, pollution is increasing from offshore oil and gas development activities (Aquarone & Adams, 2009a, 2009b), and metal pollution exists from prior mineral development activity and atmospheric deposition (Bindler et al., 2001; Larsen et al., 2001). Natural hydrocarbon seeps are located near Baffin Island to the north (Kvenvolden & Cooper, 2003).

3.2.2.1.1.2 Sediments in the Northeast and Mid-Atlantic Region

Section 3.5 (Habitats) provides a detailed discussion of substrate types within the Northeast and Mid-Atlantic Region, and is summarized here. Almost the entire continental shelf along the U.S. Atlantic coast is composed of sandy sediments. Sediments north of Cape Hatteras are dominated by quartz and feldspar from Precambrian and Paleozoic rocks that were mechanically weathered and deposited by glaciers and rivers. Silicon- and phosphorus-based sediments are locally abundant (Milliman et al., 1972). Sediment in deep areas beyond the continental shelf break is often dominated by biogenic calcareous ooze (i.e., calcium carbonate and clays) (Kennett, 1982). Nearshore areas off capes and at the mouths of bays, such as Chesapeake Bay and Delaware Bay, are influenced by longshore and cross-shelf currents as well as tidal fluctuations (McBride & Moslow, 1991; Murray & Thieler, 2004). Extensive estuaries on the Atlantic coast tend to trap much of the sediment delivered by rivers. Fine-grained sediments that reach the ocean are usually transported shoreward by tides or deposited on the continental slope and beyond.

In contrast to the surrounding areas, fine-grained, sandy clay and silt sediments occur on the continental shelf south of Nantucket Shoals and the coast of Martha's Vineyard in an area known as the "Mud Patch" (Chang et al., 2001). This is the only area of its size on the eastern U.S. continental shelf where surface sediments contain up to 95 percent silt and clay and no rock fragments (Chang et al., 2001; Churchill, 1989).

Sediment Quality in the Northeast and Mid-Atlantic Region

States bordering the Northeast U.S. Continental Shelf Large Marine Ecosystem include Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and northeast North Carolina (Figure 3.0-1 in Section 3.0, Introduction). Information regarding the current quality of sediment in nearshore areas of these states is provided below (Table 3.2-1). Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the U.S Environmental Protection Agency National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

In 2008, sediments in the northeast coastal region—Maine through Virginia—were rated 76 percent good, 11 percent fair, and 13 percent poor (no data were reported for 1 percent) in an evaluation of coastal conditions by the USEPA (U.S. Environmental Protection Agency, 2008a). Criteria used in the agency's sediment quality index included sediment toxicity, sediment contaminants, and excess sediment carbon contained in organic compounds (total organic carbon). To receive a good rating, no individual samples in the region could be rated as poor, and the rating for sediment contaminants had to be good. A fair rating indicated that none of the individual samples were rated as poor, and the sediment contaminant index was fair. Sediments in an area were rated as poor if one or more samples were rated poor (U.S. Environmental Protection Agency, 2012b).

Areas that were rated poor in the Northeast and Mid-Atlantic Region were mostly adjacent to urbanized areas and areas of past industrial activity, and included Narragansett Bay, western Long Island Sound, New York-New Jersey Harbor, and the upper portions of Chesapeake Bay. Elevated levels of sediment contaminants, including metals (e.g., arsenic, chromium, mercury, nickel, silver, and zinc), polychlorinated biphenyl, and dichlorodiphenyltrichloroethane (DDT), were the primary reason for the poor ratings in these areas. Overall, in the 2008 assessment, the region rated fair for contaminants, but good for sediment toxicity (only 4 percent of sites rated poor), and good for total organic carbon in sediments (1 percent poor) (U.S. Environmental Protection Agency, 2012b).

In 2016, the USEPA published another national coastal condition assessment, updating the 2008 assessment with 2010 sampling results (U.S. Environmental Protection Agency, 2016). In comparison to the 2008 assessment, sediment quality in the Northeast and Mid-Atlantic Region has declined, with 60 percent of sediments rated good, 20 percent rated fair, and 9 percent rated poor (data were missing for 11 percent of sampling sites). While 80 percent of sediments were rated good for contaminants, only 58 percent were rated good for sediment toxicity, which was the primary reason for the decline in overall sediment quality.

The sediment toxicity index for marine and estuarine sediments is based on the survival rate of selected estuarine amphipods when the specimens are exposed to samples collected in the field. Sediment toxicity indicates how combinations of anthropogenic and natural chemicals might affect the survival of benthic organisms.

Table 3.2-1: Sediment Quality Criteria and Index, U.S. Atlantic Coast and Gulf of Mexico

Parameter	***Site Criteria***			***Regional Criteria***		
	Good	***Fair***	***Poor***	***Good***	***Fair***	***Poor***
Sediment Toxicity	Amphipod[1] survival rate ≥ 80%	n/a	Amphipod[1] survival rate < 80%	< 5% of coastal area in poor condition	n/a	≥ 5% of coastal area in poor condition
Sediment Contaminants	No ERM[2] concentration exceeded, and < 5 ERL[3] concentrations exceeded	No ERM[2] concentration exceeded and ≥ 5 ERL[3] concentrations exceeded	An ERM[2] concentration exceeded for one or more contaminants	< 5% of coastal area in poor condition	5–15% of coastal area in poor condition	> 15% of coastal area in poor condition
Excess Sediment TOC	TOC concentration < 2%	TOC concentration 2% to 5%	TOC concentration > 5%	< 20% of coastal area in poor condition	20–30% of coastal area in poor condition	> 30% of coastal area in poor condition

Table 3.2-1: Sediment Quality Criteria and Index, U.S. Atlantic Coast and Gulf of Mexico (continued)

Parameter	Site Criteria			Regional Criteria		
	Good	Fair	Poor	Good	Fair	Poor
Sediment Quality Index	No poor ratings, sediment contaminants criteria are rated "good"	No poor ratings, sediment contaminants criteria are rated "fair"	One or more individual criteria rated poor	< 5% of coastal area in poor condition, and > 50% in good condition	5–15% of coastal area in poor condition, and > 50% in combined fair and poor condition	> 15% of coastal area in poor condition

[1]Amphipods are small animals found in a wide variety of aquatic habitats. Because they are so widely distributed, they are often used as an indicator of toxicity in sediments and water bodies.
[2]ERM (effects range-median) is the level measured in the sediment below which adverse biological effects were measured 50 percent of the time.
[3]ERL (effects range-low) is the level measured in the sediment below which adverse biological effects were measured 10 percent of the time (Long et al., 1995).
Source: (U.S. Environmental Protection Agency, 2012b)
Notes: % = percent, ≥ = equal to or greater than, < = less than, > = greater than, n/a = not applicable, TOC = total organic carbon

The impact that anthropogenic activities can have over the long term is exemplified by changes observed in Long Island Sound, where development dates to colonial times. Mean concentrations of metals in Long Island Sound have increased substantially and steadily since pre-industrial levels (Table 3.2-2) (Varekamp et al., 2014). The concentrations of silver, cadmium, copper, and mercury showed the greatest increases (between 30 and 6.5 times over background levels); lead, arsenic, and zinc have increased between 2.4 and 3.6 times; and chromium, vanadium, nickel, and barium concentrations have remained close to background levels.

Table 3.2-2: Comparison of Mean Pre-Industrial and Post-Industrial Metal Concentrations in Sediments in Long Island Sound with Sediment Effects Thresholds

Metal	Pre-Industrial Background Mean Concentration (µg/g)	Post-Industrial Mean Concentration (µg/g)	Mean Enrichment Factor	National Oceanic and Atmospheric Administration	
				Effects Range-Low (ppm)	Effects Range-Median (ppm)
Cadmium	0.2	2	9.9	1.2	9.6
Chromium	59	78	1.3	81	370
Copper	8	117	14.6	34	270
Lead	23	83	3.6	46.7	218
Mercury	0.1	0.7	6.5	0.15	0.71
Nickel	25	26	1.0	20.9	51.6
Silver	0.05	1.5	29.8	1.0	3.7
Zinc	68	160	2.4	150	410
Arsenic	2.5	6	2.5	8.2	70
Vanadium	90	101	1.1	NA	NA

Table 3.2-2: Comparison of Mean Pre-Industrial and Post-Industrial Metal Concentrations in Sediments in Long Island Sound with Sediment Effects Thresholds (continued)

Metal	***Pre-Industrial Background Mean Concentration (µg/g)***	***Post-Industrial Mean Concentration (µg/g)***	***Mean Enrichment Factor***	***National Oceanic and Atmospheric Administration***	
				Effects Range-Low (ppm)	***Effects Range-Median (ppm)***
Barium	377	230	0.6	NA	NA

Effects range-low is the level measured in the sediment below which adverse biological effects were measured 10 percent of the time Long et al. (1995).
Effects range-median is the level measured in the sediment below which adverse biological effects were measured 50 percent of the time.
Enrichment Factor is the ratio of the postindustrial and preindustrial concentrations and is a measure of the change in concentration over time (e.g., the concentration of cadmium has increase 9.9 times since preindustrial levels)
Source: Varekamp et al. (2014)
Notes: µg /g = micrograms per gram, ppm = parts per million, NA = Not applicable

The distribution of metals within sediments in the sound varied widely, as did maximum concentrations, and was strongly correlated with fine-grained sediments rich in organic material. With the exception of arsenic, all post-industrial metal concentrations exceeded Effects Range-Low levels and were less than Effects Range-Median levels; the concentration of arsenic was less than the Effects Range-Low level; however, the authors note that there were fewer samples for arsenic available for analysis (Table 3.2-2). Increases in metal concentrations were closely linked to the industrialization of the region, and included many non-point source discharges, such as urban runoff, and point source discharges, such as effluent from waste water treatment facilities located along tributaries of the sound. Overall, concentrations of metal contaminants increased with proximity to New York City, lending additional support to the close association between industrialization and increased sediment contamination.

Polycyclic aromatic hydrocarbons and polychlorinated biphenyls, two widely dispersed contaminants found worldwide in marine sediments have been present in the Study Area for decades (Boehm & Requejo, 1986; Farrington & Takada, 2014; Farrington & Tripp, 1977; Lamoreaux & Brownawell, 1999). The source of most polycyclic aromatic hydrocarbons introduced into the environment (terrestrial and marine) is from the incomplete combustion of biofuels (Ravindra et al., 2008). Aromatic hydrocarbons can enter the marine environment through multiple means, including as urban runoff, effluent from outfalls serving densely populated urban regions, and as deposition from airborne particulate matter (Farrington & Takada, 2014). While there are natural sources of polycyclic aromatic hydrocarbons, such as wildfires and volcanic eruptions, the primary source of aromatic hydrocarbons in the marine environment is emissions from the anthropogenic combustion of fossil fuels, including oil and coal (Farrington & Takada, 2014; Ravindra et al., 2008).

Polychlorinated biphenyls are anthropogenic organic chemicals made up of carbon, hydrogen, and chlorine atoms, and were produced in the United States from 1929 until they were banned in 1979, because of growing concerns over their toxicity and links to a number of adverse health effects, including cancers, neurological disorders, reproductive effects, and immune system effects (Manta Trust, 2017). Even though the production of polychlorinated biphenyls has not occurred in the United States for decades, the chemicals are present in products manufactured prior to 1979 and still in use today (e.g., electrical transformers, cable insulation, paints, and plastics) as well as imported products from countries where polychlorinated biphenyls have not been banned for as long (or at all). The chemicals are resistant to breakdown in the environment, including in the marine environment, enabling them to persist in a variety forms far from where they originated (Farrington & Takada, 2014; Manta Trust, 2017).

Dichlorodiphenyltrichloroethane (DDT) is a pesticide that was widely used in the United States in the 1950s and 1960s until its production and use was banned in 1972 over concerns of adverse environmental effects (e.g., thinning of bird egg shells resulting in poor reproductive success in multiple species) (Sericano et al., 2014).

The concentration of aromatic hydrocarbons and polychlorinated biphenyls in sediments is positively correlated with total organic carbon content in sediments. Fine-grained sediments (silts and clays) have higher total organic carbon levels than sandy sediments, and areas dominated by fine-grained sediments, like the Mud Patch, tend to act as sinks for polycyclic aromatic hydrocarbons and other contaminants like polychlorinated biphenyls (Boehm & Requejo, 1986; Lamoreaux & Brownawell, 1999). Disturbance of seafloor sediments with high concentrations of these chemical contaminants can cause resuspension, increased bioavailability, and facilitate the widespread distribution of these contaminants. The use of equipment and products manufactured prior to 1979 with polychlorinated biphenyls can continue to introduce the contaminant into the environment.

Farrington and Takada (2014) provide a summary of four decades of research on persistent organic pollutants, including polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and dichlorodiphenyltrichloroethane (DDT). Concentrations of polycyclic aromatic hydrocarbons measured in benthic dwelling bivalves, so called sentinel organisms, exceeded the National Oceanic and Atmospheric Administration thresholds for environmental effects in multiple samples collected in the northeast and mid-Atlantic regions (Table 3.2-3). Although a number of sites have exceeded effects thresholds, (Farrington & Takada, 2014) the overwhelming trend is that concentrations of these three chemical contaminants is decreasing in bivalves, a proxy for sediments, along the entire U.S. coastline. Only one site in the Study Area, off the coast of North Carolina, is showing an increase in the concentration of polycyclic aromatic hydrocarbons, and no sites in the Study Area are showing an increase in concentrations of polychlorinated biphenyls. Concentrations of dichlorodiphenyltrichloroethane (DDT) are also decreasing in coastal areas along the U.S. coastline (as measured in bivalve bioassays) (Sericano et al., 2014); however, dichlorodiphenyltrichloroethane (DDT) is also resistant to breakdown in the environment, as are its breakdown products. Nevertheless, by 2050, the concentration of DDT and its breakdown products are expected to be at 10 percent of current levels (Sericano et al., 2014).

Table 3.2-3: Comparison of Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls and dichlorodiphenyltrichloroethane in Sediment Samples with Sediment Guidelines Developed by the National Oceanic and Atmospheric Administration

Sediment Contaminant	*Contaminant Concentration (ppb)*				*National Oceanic and Atmospheric Administration*	
	Northeast	*Mid-Atlantic*	*Southeast*	*Gulf of Mexico*	*Effects Range-Low*[1]	*Effects Range-Median*[2]
PAHs	63–7,561	47–10,717	47–2,511	47–2,511	4,022	44,792
PCBs	3–1,413	4–157	4–157	4–157	22.7	180

Table 3.2-3: Comparison of Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls and dichlorodiphenyltrichloroethane in Sediment Samples with Sediment Guidelines Developed by the National Oceanic and Atmospheric Administration (continued)

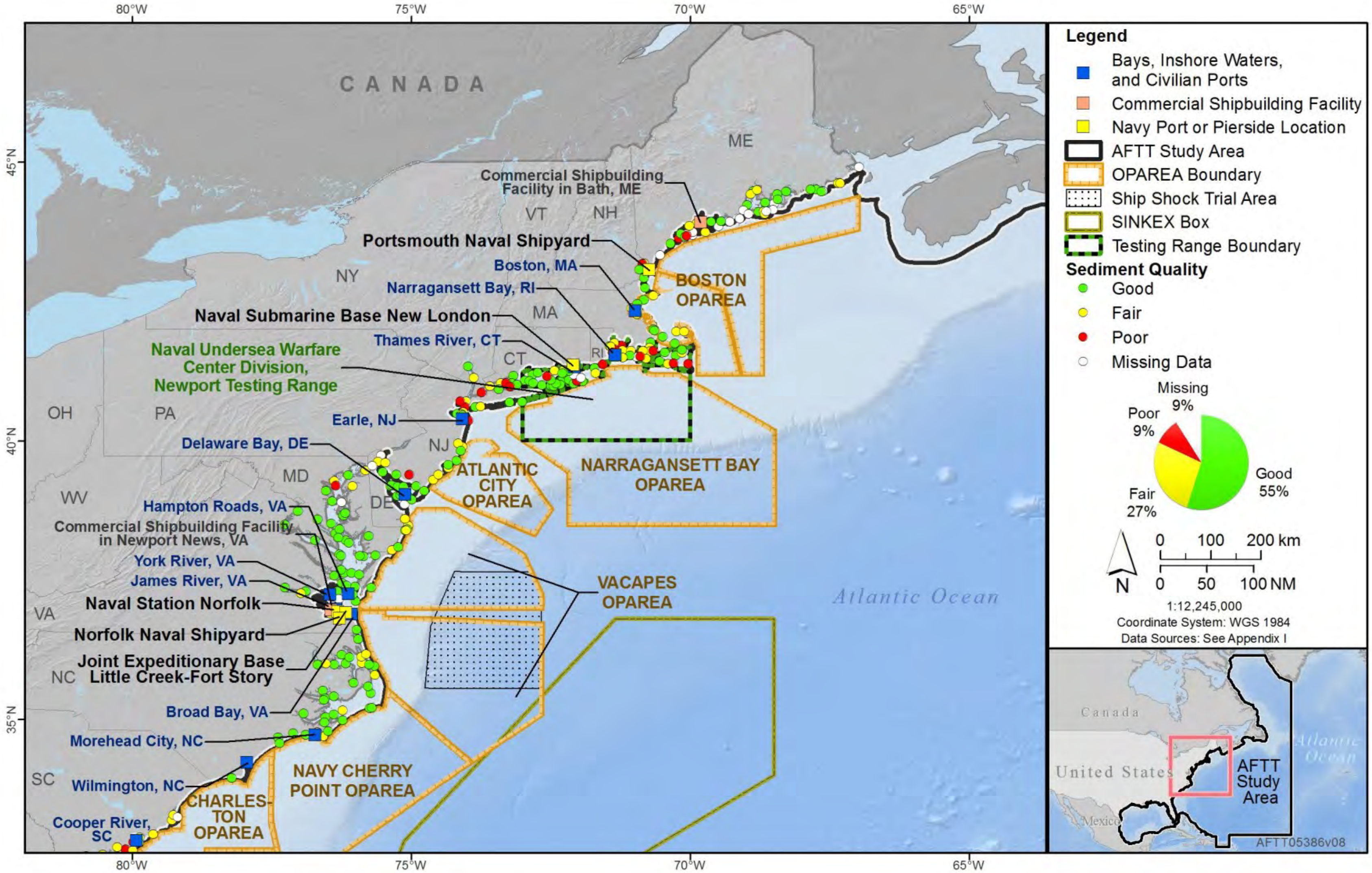
Sediment Contaminant	*Contaminant Concentration (ppb)*				*National Oceanic and Atmospheric Administration*	
	Northeast	*Mid-Atlantic*	*Southeast*	*Gulf of Mexico*	*Effects Range-Low[1]*	*Effects Range-Median[2]*
DDT[3]	0.001 – 0.15			<MDL– 0.087	1.58	46.1

[1]Effects range-low is the level measured in the sediment below which adverse biological effects were measured 10 percent of the time Long et al. (1995).
[2]Effects range-median is the level measured in the sediment below which adverse biological effects were measured 50 percent of the time.
[3]Data are from 2009: Sericano et al. (2014).
Source: Farrington and Takada (2014)
Notes: PAHs = polycyclic aromatic hydrocarbons, ppb = parts per billion, PCBs = polychlorinated biphenyls, DDT = dichlorodiphenyltrichloroethane, MDL = minimum detection level

Maine. Sediment quality along the Maine coast was rated 51 percent good and 12 percent poor; 37 percent of sampling site data were labeled as missing (Figure 3.2-2). Concerns related to sediments in Maine include polychlorinated biphenyls, mercury, and dioxin. As a result, seafood consumption advisories have been issued. These concerns involve all the state's estuarine and marine habitats. In much smaller areas, bacteria, low dissolved oxygen, copper contamination, and polycyclic aromatic hydrocarbons were also identified (State of Maine Department of Environmental Protection, 2006). Wade and Sweet (2005) reported that sediment from the interior of Casco Bay (Portland, Maine) contains elevated levels of trace metals, polychlorinated biphenyls, dichlorodiphenyltrichloroethane (DDT), and the pesticide chlordane.

New Hampshire. Sediment quality along the New Hampshire coast was rated 67 percent good, 17 percent fair, and 17 percent poor (Figure 3.2-2). Concerns related to sediments in New Hampshire include included metals, polycyclic aromatic hydrocarbons, and dichlorodiphenyltrichloroethane (DDT). These concerns involve all the state's estuarine and marine waters. Marine sediment samples were analyzed for heavy metals (cadmium, chromium, copper, lead, mercury, nickel, and zinc) and organic compounds (polychlorinated biphenyls and polycyclic aromatic hydrocarbons). Results indicate that, with few exceptions, the levels of contaminants detected in shellfish and sediment were within the range of contaminants found elsewhere in New England, other regions of the United States, and the world. Two estuarine areas were impaired due to pesticides. Ocean waters are listed as impaired due to dioxin, mercury, and polychlorinated biphenyls. As noted above, concerns are related to seafood consumption (Comstock et al., 2008; Paliwoda et al., 2016).

Massachusetts. Sediment quality along the Massachusetts coast was rated 67 percent good, 6 percent fair, and 24 percent poor; 5 percent of sampling site data were labeled as missing (Figure 3.2-2). Most poor sediment was concentrated in the Boston Harbor area, which rated as 100 percent poor. For Buzzards Bay, sediment quality was rated 50 percent good and 40 percent poor; 10 percent of sampling site data were labeled as missing.



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

Figure 3.2-2: Sediment Quality Ratings for the Northeast and Mid-Atlantic Coast

Rhode Island. Sediment quality along the Rhode Island coast was rated 64 percent good, 7 percent fair, and 29 percent poor (Figure 3.2-2). In Narragansett Bay sediment quality was rated 50 percent good and 50 percent poor. Issues included high concentrations of metals, dichlorodiphenyltrichloroethane (DDT), and polychlorinated biphenyls. Contaminated sediments were listed as a concern for 1 square mile ($mi.^2$) of estuarine habitat in Rhode Island. The issue involved "legacy/historical pollutants," such as polychlorinated biphenyls in Narragansett Bay (Rhode Island Department of Environmental Management, 2008). No data were available for Block Island Sound.

Connecticut. Long Island Sound comprises most of the nearshore and estuarine habitat along the Connecticut coast. Sediment quality in Long Island Sound was rated 71 percent good, 14 percent fair, and 14 percent poor (Figure 3.2-2). Sampling indicated a trend of decreasing impacts from runoff moving east from New York City (Mecray & Buchholtz ten Brink, 2000; Varekamp et al., 2014). As discussed above (see Section 3.2.2.1.1.2, Sediments in the Northeast and Mid-Atlantic Region), sediments in Long Island Sound have been enriched many times over pre-industrial background levels with silver, cadmium, copper, mercury, and lead. Metal concentrations have been decreasing since the peak levels in the 1970s, due in large part to upgrades of sewage treatment facilities to meet requirement of the Clean Water Act and the laws strictly regulating the use of persistent chemical contaminants, such as polychlorinated biphenyls (Varekamp et al., 2014). However, contaminants still occur in concentrations that impact habitat, particularly along the Connecticut coast, which borders the western portion of Long Island Sound where 50 percent of sediments are rated as poor.

New York/New Jersey. Sediment quality in the New York-New Jersey Bay were rated 100 percent poor on the New York side of the Bay, closer to New York City, and as 67 percent good and 33 percent poor on the New Jersey side (Figure 3.2-2). Issues included elevated concentrations of metals and polychlorinated biphenyls resulting from decades of industrialization and unregulated use and disposal of chemical contaminants (Varekamp et al., 2014). Information for Long Island Sound sediment is presented under the entry for Connecticut and above in Section 3.2.2.1.1.2 (Sediments in the Northeast and Mid-Atlantic Region). Sediment quality in Barnegat Bay on the Atlantic coast was rated 50 percent good and 50 percent poor. Sediment quality for Peconic Bay was rated 100 percent good. Information for Delaware Bay is provide under the entry for Delaware.

Delaware. Sediment quality in Delaware Bay was rated 67 percent good; however 33 percent of sampling site data were missing (Figure 3.2-2). The highest levels of sediment contaminants were near Philadelphia and the Maurice River. There may be some point sources for metals, but organic contaminants appear to be primarily from nonpoint sources. Metals and organic contaminants in sediments tend to decrease from upper to lower Delaware Bay. Sediments in coastal zones have trace amounts of metals and organic contaminants (Hartwell & Hameedi, 2006).

Maryland. Maryland's coastal bays provide a natural buffer between Maryland's Eastern Shore and the Atlantic Ocean. Sediment quality in Maryland's three largest coastal bays on the Atlantic coast, Chincoteague Bay, Assawoman Bay, and Isle of Wight Bay, were all rated 100 percent good in the National Coastal Condition Assessment (U.S. Environmental Protection Agency, 2016) (Figure 3.2-2). However, the Maryland Coastal Bays Program assess other metrics, including the density of bottom dwelling hard clams and seagrasses, which are an indicator of the quality of benthic habitat. According to the Maryland Coastal Bays Program (2015) "report card," the six coastal bays, including the three already mentioned, collectively received a grade of C+, on a scale of A (good to very good) to F (very poor), for 2014 on the program's index for characterizing the health of each coastal bay. Factors that contribute to the grade include water quality indicators (e.g., chlorophyll-*a*, dissolved oxygen), as well as, seagrass and hard clam densities. Chincoteague Bay (B-) scored well for seagrasses but poor for hard clams. Assawoman Bay (C) had poor to very poor grades for both seagrasses and hard clams, and Isle of Wight Bay (C) also received a very poor grade for seagrasses and saw declines in the density of hard clams. While sediment quality may be good, as reported in the coastal condition assessment, other habitat metrics provide additional insight into the suitability of the benthic habitat for sustaining biological resources.

Virginia. The James River flows into the lower Chesapeake Bay north of Norfolk Harbor. Sediment quality in the lower James River is rated 50 percent good and 50 percent poor (Figure 3.2-2). Sediment quality in the Elizabeth River, which flows through heavily industrialized and urban areas in the cities of Norfolk, Portsmouth, and Chesapeake was rated 100 percent poor. On Virginia's Atlantic coast, Back Bay, which is adjacent to Back Bay National Wildlife Refuge, received a sediment quality rating of 100 percent good.

North Carolina. Sediment quality in Albemarle Sound was rated 83 percent good and 17 percent poor. Sediment quality in Pamlico Sound located south of Albemarle Sound and west of Cape Hatteras is rated 86 percent good and 14 percent poor. Currituck Sound, located along the Atlantic coast north of Albemarle Sound received a rating of 100 percent good for sediment quality (Figure 3.2-2). Hackney et al. (1998) stated that, "between 37.5 and 75.8 percent of surface sediments in North Carolina's sounds and estuaries were contaminated, and between 19 and 36 percent were highly contaminated." Contaminants included nickel, arsenic, dichlorodiphenyltrichloroethane (DDT), chromium, polychlorinated biphenyls, and mercury. The most contaminated areas were the Neuse and Pamlico Rivers. In general, areas with limited tidal flushing and high river discharge were most contaminated. Hyland et al. (2000), reported that 38 percent of the total area of North Carolina estuaries had at least one chemical contaminant present at a concentration in excess of levels at which biological effects can be expected. The most common contaminants in their study were arsenic, mercury, chromium, nickel, pesticides, and polychlorinated biphenyls. There were relatively few degraded sites in the open portions of Pamlico Sound and smaller estuaries south of Cape Lookout.

Chesapeake Bay. The Chesapeake Bay watershed includes portions of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia. In order to simplify the discussion and reduce repetition, sediment issues in Chesapeake Bay are not reviewed on a state-by-state basis because: (1) many of the sediment issues are common to most or all of these bordering states, and (2) Navy training and testing activities discussed in this Environmental Impact Statement/Overseas Environmental Impact Statement are limited to the extreme southeast portion of the bay and do not appreciably impact sediment quality in the bay as a whole.

Point source pollution, urban and suburban runoff from continued development, atmospheric deposition, and agricultural practices in the bay's watershed introduce contaminants into the bay (Coxon et al., 2016). The U.S. Environmental Protection Agency (2012b) reports widespread occurrence of polychlorinated biphenyls, polycyclic aromatic hydrocarbons, herbicides, and mercury. Localized occurrence of pesticides, including dichlorodiphenyltrichloroethane (DDT), and certain metals (i.e., aluminum, chromium, iron, lead, manganese, and zinc) within the bay also contribute to degraded habitat in those areas.

In 2014, the Chesapeake Bay Program adopted a goal to create or reestablish 85,000 acres (ac.) of tidal and non-tidal wetlands in the bay's watershed by 2025, with the ultimate goal of reducing the bay's Total Maximum Daily Load, a measure of pollutants entering the bay. The bulk of the created or reestablished wetlands acreage (83,000 ac.) would be on agricultural lands, which are significant source of point source pollutants. As of 2016, 7,623 ac. have been created or reestablished on formerly agricultural lands, which is 7.45 percent of the overall goal (Bonfil et al., 2008).

Fish consumption advisories have been issued in all watershed states primarily out of concerns for contamination from mercury and polychlorinated biphenyls (Bonfil et al., 2008). Chesapeake Bay and several small tidal tributaries have had fish advisories for polychlorinated biphenyls in place since 2004 (Virginia Department of Public Health, 2016).

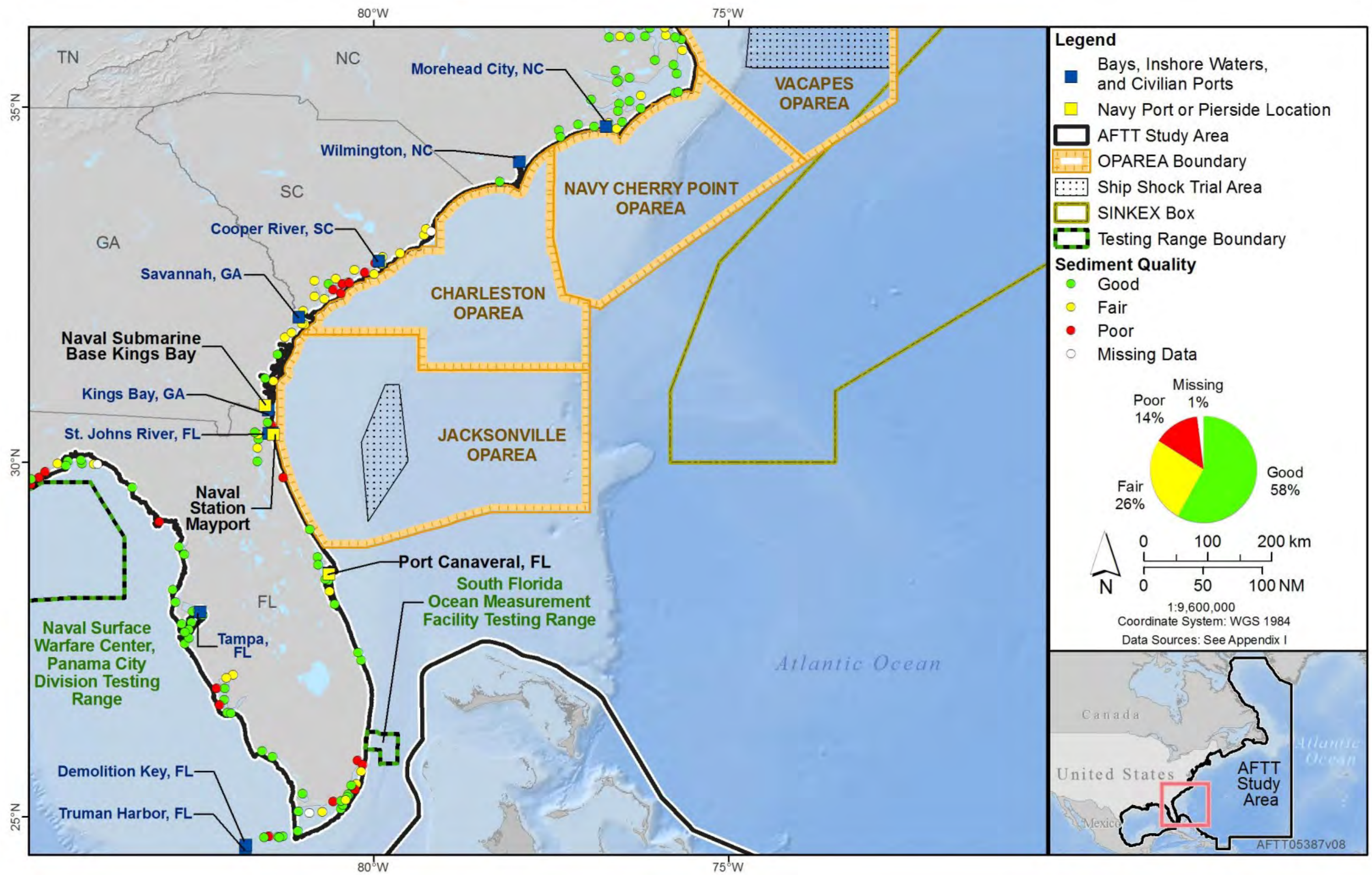
3.2.2.1.1.3 Sediments in the Southeast Region

Moving south from Cape Hatteras, coastal sediment changes from largely land-based sources to largely marine-based sources. Weathering of sediment in the piedmont and coastal plain provinces in the southeast is mostly chemical; deposition of sediment is mostly by rivers. Sediment farther north was more heavily influenced by mechanical (glacial) processes and glacial deposition. Off the coast of the Carolinas, the calcium carbonate content of sediment is between 5 and 50 percent; this increases to 100 percent on the East Florida Shelf. Sources of calcium carbonate include the shells of molluscs, echinoderms, barnacles, coralline algae, foraminifera; and ooids, small (0.25 to 2 mm) spherical deposits of calcium carbonate (Milliman et al., 1972). Some areas of the continental shelf along the southeast coast have been swept clean of sediment by the Gulf Stream, exposing the underlying bedrock (Riggs et al., 1996). Sediment on the continental shelf off the east coast of Florida is primarily composed of silt and clay sized particles (Milliman et al., 1972).

Sediment Quality in the Southeast Region

States in the Southeast Region bordering on the Southeast U.S. Continental Shelf Large Marine Ecosystem include southeastern North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes occurring within this region, and Figure 3.0-5 for bathymetry in the Southeast region. The current quality of sediments in nearshore areas in this regions is described below. Overall sediment quality for the coastal areas from North Carolina through the southern tip of Florida is rated as good. Sediments for 80 percent of this coastal area rated good, 2 percent rated fair, and 12 percent rated poor (6 percent of the data was missing) (Figure 3.2-3). Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016). Concentrations of the contaminant chemicals polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and dichlorodiphenyltrichloroethane (DDT) for the southeast region are provided in (Table 3.2-3). Windom et al. (1989) noted that it is not unusual for natural trace metal concentrations in coastal sediment to range over two orders of magnitude, particularly in the southeastern United States. Boehm and Gequejo (1986) noted that sediment hydrocarbons along the southeast coast were less than 10 parts per million (ppm) in all cases.

North Carolina. Information regarding sediment along the North Carolina coast is provided in Section 3.2.2.1.1.2 (Sediments in the Northeast and Mid-Atlantic Region).



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

Figure 3.2-3: Sediment Quality Ratings for the Southeast Coast

South Carolina. Sediment quality along the South Carolina coast was rated 62 percent good and 33 percent poor; 5 percent of sampling site data were missing (Figure 3.2-3). Just over 4 percent of the state's estuarine area (17.3 $mi.^2$) is impaired by metals, mostly by copper, but also nickel and zinc (South Carolina Department of Health and Environmental Control, 2008). A 2006 study found that 33 monitoring points (12 open water and 21 tidal creeks) had at least one contaminant that exceeded concentrations shown to have biological effects in 10 percent of published studies. Contaminants included polycyclic aromatic hydrocarbons, dichlorodiphenyltrichloroethane (DDT), and five metals: arsenic, cadmium, copper, lead, and zinc (Van Dolah et al., 2006).

Georgia. Sediment quality along the Georgia coast was rated 71 percent good, 22 percent fair, and 7 percent poor (Georgia Department of Natural Resources, 2010). In terms of toxicity, 97 percent of Georgia's sediments rated as good and 2 percent rated as poor; 1 percent of sampling site data were missing. In terms of sediment likely to have biological effects, 72 percent rated good, 24 percent rated fair, and 4 percent rated poor. Four miles of coastal streams were reported as impaired by mercury, and 2 miles (mi.) were impaired by elevated levels of cadmium. Pesticides (in fish tissue) impaired 8 mi. of coastal streams, and polychlorinated biphenyls (in fish tissue) impaired 26 mi. of coastal streams (Georgia Department of Natural Resources, 2010). Hyland et al. (2000) examined the presence of a wide variety of trace metals and persistent organic pollutants in the water and sediment between 2 and 77 kilometers (km) off the Georgia coast. The maximum values found were well below levels expected to induce biological effects.

Florida. Sediment quality along the Atlantic coast of Florida varied by location. Sediments in the Matanzas River, which runs parallel to coastal route A1A and empties into the ocean at the city of St. Augustine, rated as 100 percent poor (Figure 3.2-3). Sediment quality in the Mosquito Lagoon just north of Cape Canaveral rated as 100 percent good. Sediments in the Indian River Lagoon also rated as 100 percent good based on total organic carbon content. Farther south, sediment quality in Biscayne Bay, located adjacent to and south of Miami, was rated 60 percent good and 40 percent poor. In a discussion of sediment quality guidelines, MacDonald et al. (1996) noted that Biscayne Bay is contaminated with trace metals, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and pesticides, and that sediment from the St. Johns River had elevated levels of polychlorinated biphenyls. Windom et al. (1989) found lead and zinc-contaminated sediment from Biscayne Bay, apparently influenced by discharge from the Miami River.

In 2010, the Florida Department of Environmental Protection (2010) assessed metal concentrations in estuarine sediments and determined that concentrations were most often above background levels for cadmium, mercury, lead, and zinc. Also, 70 percent of samples tested for organic chemicals indicated the presence of polycyclic aromatic hydrocarbons. The following metals impaired estuarine habitat: copper (100 $mi.^2$), iron (98 $mi.^2$), nickel (40 $mi.^2$), arsenic (8 $mi.^2$), and lead (7 $mi.^2$). Copper has also impaired 83 mi. of Florida's 8,400 mi of coastal waters (Florida Department of Environmental Protection, 2010). More than 993,000 acres of the 1,671,159 acres assessed by the Florida Department of Environmental Protection in 2016 were impaired with at least one contaminant (Washington Tribes, 2015). A study of sediment in south Florida estuaries by Macauley et al. (2002) also found that elevated concentrations of pesticides were fairly common, but that elevated levels of metals were not as common.

3.2.2.1.1.4 Sediments in the Gulf of Mexico Region

States bordering the Gulf of Mexico Large Marine Ecosystem include the west coast of Florida, Alabama, Mississippi, Louisiana, and Texas. Refer to Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within the Gulf of Mexico Large Marine Ecosystem and Figure 3.0-6 for bathymetry in the Gulf of Mexico region. Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the USEPA’s National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

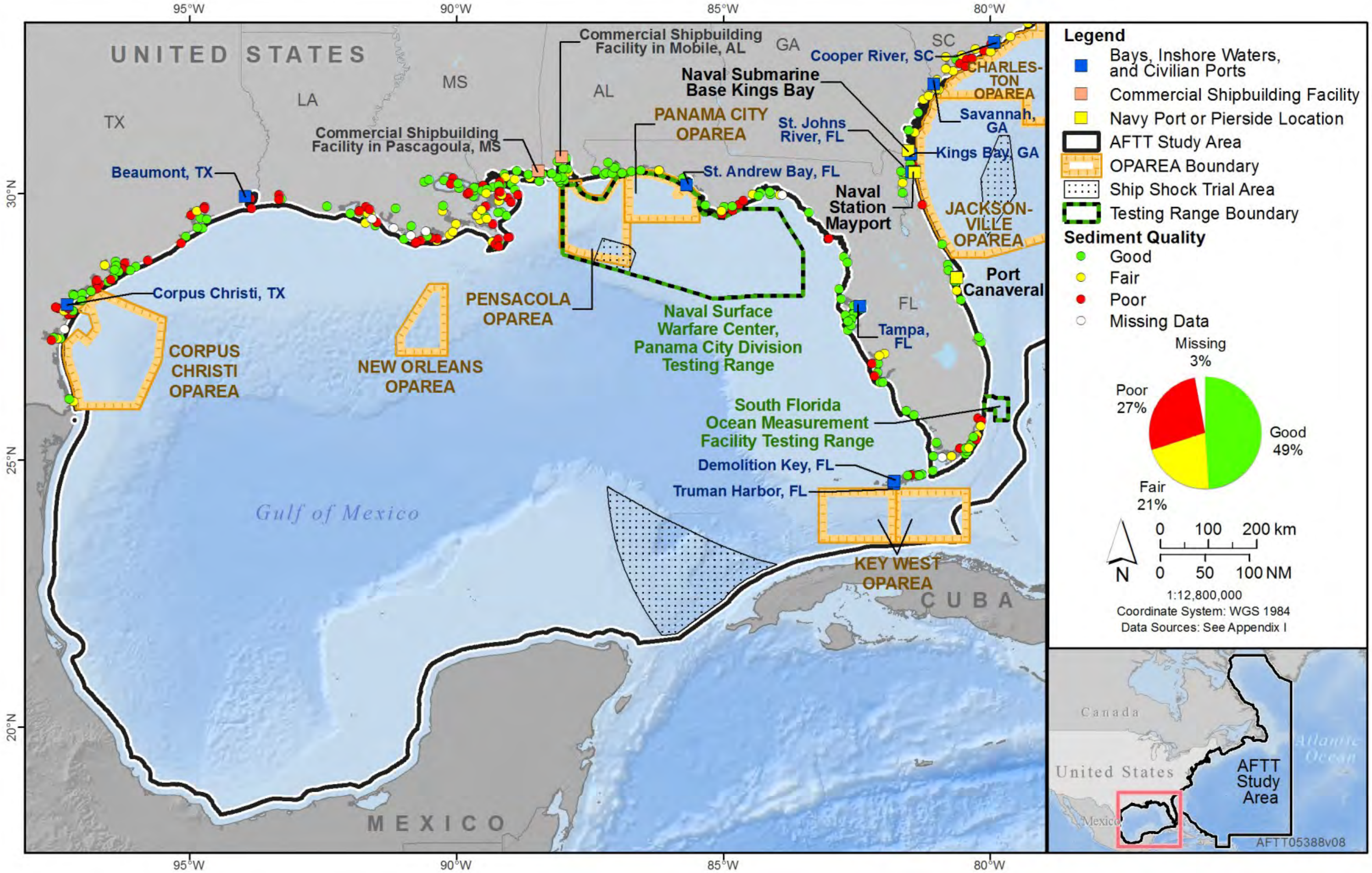
The western and central portions of the Gulf of Mexico are dominated by sediment deposition from the Rio Grande and Mississippi River systems, mostly in the form of sandstone and shale (Galloway et al., 2000). DeSoto Canyon, a submarine feature southwest of Pensacola, Florida, marks the transition between the Mississippi River-influenced sediment to the west (Alabama, Mississippi, Louisiana, and Texas) and the carbonate-dominated sediment to the east and south along western Florida (Gearing et al., 1976). The Naval Surface Warfare Center, Panama City Division Testing Range straddles this transition area. Sediment is predominantly carbonate-sand mixture. Carbonate sources include corals, molluscs, and marine microbes. The amount of organic material mixed with the sand generally increases with the distance from shore. Like other deep ocean areas, the central portions of the Gulf of Mexico are dominated by clay-sized particles (less than 0.002 mm).

Sediment Quality in the Gulf of Mexico Region

Information regarding the quality of sediments in nearshore areas of the states bordering the Gulf of Mexico—Florida, Alabama, Mississippi, Louisiana, and Texas—is provided below. Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the USEPA’s National Aquatic Resource Surveys database *(U.S. Environmental Protection Agency, 2016)*. In the Gulf of Mexico—from the southern tip of Florida to the Texas-Mexico border—sediment quality was rated 54 percent good, 17 percent fair, and 25 poor; 4 percent of sampling site data were reported as missing (Figure 3.2-4).

According to Summers et al. (1996), of the sites in the Gulf of Mexico enriched by three or more metals, 44 percent occur near populated areas and 56 percent occur in agricultural watersheds or the Mississippi River. Many contaminated sites are in watersheds with Superfund sites established under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 or are identified by the USEPA National Sediment Inventory as “areas of probable concern” (U.S. Environmental Protection Agency, 2008a). Wade et al. (1988) evaluated coastal sediment at 51 sites in the Gulf of Mexico chosen for their distance from known point sources of polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and chlorinated pesticides. The concentrations of the 18 polycyclic aromatic hydrocarbons tested averaged 507 parts per billion (ppb) (range: less than 5 ppb to 36,701 ppb). Eleven percent of all samples had no detectable polycyclic aromatic hydrocarbons. Polychlorinated biphenyl concentrations ranged from less than 5 to 50 ppb, and chlorinated pesticides ranged from less than 0.02 to 5 ppb, with most samples below the limits of detection.

The Gulf of Mexico has several natural hydrocarbon seeps (Kvenvolden & Cooper, 2003). In the eastern Gulf of Mexico, Boehm and Gequejo (1986) found that sediment hydrocarbons are mainly marine in origin, although the Loop Current carries hydrocarbon-laden sediment from the Mississippi River into the eastern Gulf (concentration: 0.4–0.5 ppm). West of the Mississippi River, the concentration of hydrocarbons increases in shallow (less than 30 feet [ft.]) nearshore areas (20–70 ppm), and those increases are predominantly from anthropogenic sources.



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

Figure 3.2-4: Sediment Quality Ratings for the Gulf of Mexico Coast

Along the Texas coast, sediment hydrocarbon concentrations ranged from 0.5 to 20 ppm; proximity to urban and riverine sources increased the contribution from man-made sources. Farther offshore, hydrocarbons carried on wind as a result of burning fuels were more common.

Concentrations of the contaminant chemicals polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and dichlorodiphenyltrichloroethane (DDT) for the Gulf of Mexico region are provided in Table 3.2-3.

Coastal sediments rated as 93 percent good for contaminants (3 percent fair and 0 percent poor), but just 46 percent good for toxicity (15 percent fair and 25 percent poor). The poor rating for toxicity is the primary reason the extent of the region rated as good for sediment quality decreased from nearly 70 to 54 percent between 2006 and 2010. Contaminants resulting in elevated levels of toxicity included metals, pesticides, polychlorinated biphenyls, and, occasionally, polycyclic aromatic hydrocarbons (U.S. Environmental Protection Agency, 2016). Except where otherwise indicated, information provided below was drawn from the National Coastal Condition Aquatic Resource Surveys (U.S. Environmental Protection Agency, 2016).

The Deepwater Horizon oil spill occurred in the Gulf of Mexico in 2010, leaking millions of gallons of oil into the Gulf over 87 days. The impact area extended from the Florida panhandle to western Louisiana, and 143 of the sites sampled during the 2010 survey fell within those boundaries (U.S. Environmental Protection Agency, 2016). The same sampling protocols used to collect samples for previous coastal condition assessments were used during the 2010 survey, which allowed for a comparison with past survey results. Sediment toxicity in the areas impacted by the oil spill showed an increase from 8 percent in the 2005-2006 survey to 27 percent in the 2010 survey, which was a significantly greater increase than observed in other areas of the Gulf.

Florida. Within the Gulf of Mexico, the sediment quality in Charlotte Harbor, Tampa Bay, and Sarasota Bay were all rated 100 percent good (Figure 3.2-4). Sediment quality in Florida Bay, located between the southern tip of Florida and the Florida Keys, was rated 83 percent poor with 17 percent of sampling site data reported as missing. Florida Bay was severely impacted by a seagrass die-off in 1987, which led to subsequent increases in turbidity and the frequency of algal blooms (Boyer et al., 1999). Restoration of the bay is dependent on reestablishing seagrass communities to their historic state. Modeling by Herbert et al. (2011) predicts that increasing the freshwater inflow from the Everglades would substantially alter conditions within the eastern portion of the bay and create favorable habitat for seagrasses that were present in the bay prior to the die-off.

Sediment samples from Pensacola Bay near port facilities were contaminated by lead and zinc (Windom et al., 1989). Lewis et al. (2001) noted that sediment in three bayous of Pensacola Bay contained, on average, as much as 10 times more total heavy metals (e.g., cadmium, copper, and zinc) than sediment collected in Pensacola Bay near the entrance to the bayous. Pesticide concentrations were as much as 45 times greater in the bayou sediment than in those from Pensacola Bay. The authors noted that the bayous were acting as sinks or reservoirs for many contaminants, reducing their transport and availability in Pensacola Bay. The probable source of the contamination was storm water runoff from urbanized watersheds. The authors also indicated that metals and persistent organic pollutant levels in three bayous of Pensacola Bay decreased with distance from shore (seaward).

MacDonald et al. (1996) noted that sediment from Tampa Bay and Pensacola Bay is contaminated with trace metals, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and pesticides. Sediment from Choctawhatchee Bay and St. Andrew Bay is contaminated by metals, polycyclic aromatic hydrocarbons, and pesticides; and sediments from St. Andrew, Apalachicola, Naples, Rookery bays, and Charlotte Harbor had elevated levels of polychlorinated biphenyls. As noted above, more recent data indicate that sediment quality has improved in Tampa Bay and Charlotte Harbor (and possibly in other locations as well) since the mid-1990s.

Alabama. Mobile Bay make up nearly the entire Alabama coastline. Sediment quality in Mobile Bay was rated 92 percent good and 8 percent poor (Figure 3.2-4). Mobile Bay, in addition to the sources of polycyclic aromatic hydrocarbons common to a major port, is also the site of coal burning facilities, natural gas production facilities, and drilling platforms (Peachey, 2003). The Alabama coast has impaired ocean and estuarine habitat due to mercury (201 mi.^{2}) and thallium (94 mi.^{2}) (Alabama Department of Environmental Management, 2010). According to Peachey (2003), Mobile Bay and eight smaller bodies of water were designated as impaired due to high levels of pesticides, persistent organic pollutants, and metals. The study found that the level of polycyclic aromatic hydrocarbons in bay sediments decreased from the upper bay to the lower bay, and that the main source of the polycyclic aromatic hydrocarbons was the burning of fossil fuels.

Mississippi. Sediment quality in the Mississippi Sound was rated 86 percent good and 14 percent poor (Figure 3.2-4). Most sites sampled along the Mississippi coast indicated good sediment quality, including in Biloxi Bay and the eastern portion of Chandeleur Sound.

Louisiana. Louisiana has numerous coastal water bodies that were assessed as part of the national coastal condition assessment (U.S. Environmental Protection Agency, 2016); however, sediment quality in the larger coastal bays and in smaller bays adjacent to the Gulf of Mexico are most relevant to the analysis in the EIS/OEIS. Sediment quality in the western portion of Chandeleur Sound was rated 50 percent good and 50 percent poor (Figure 3.2-4). Sediment quality in Black Bay, which is closer to shore than Chandeleur Sound and downstream of New Orleans, was rated 100 percent poor. East Bay is located at the mouth of the Mississippi River and adjacent to the southernmost coastline in Louisiana. Sediments in East Bay were rated 33 percent good and 67 percent poor. Sediments in coastal areas downstream of New Orleans and other areas receiving outflow from the Mississippi River have historically been affected by polycyclic aromatic hydrocarbons, pesticides, and some heavy metals (Santschi et al., 2001; Van Metre & Horowitz, 2013; Wang et al., 2014). In addition, polycyclic aromatic hydrocarbons, which are associated with petroleum products, were detected farther from shore in sediments on the continental shelf; however these hydrocarbons differed in chemical structure from those found in nearshore marsh sediments, indicating that the shelf hydrocarbons originated from offshore sources rather than urban runoff or atmospheric deposition (Wang et al., 2014). Farther west and adjacent to undeveloped coastline, sediment quality in Caillou Bay and Terrebone Bay were rated 100 percent good. Sediment quality in Atchafalaya Bay at the mouth of the Atchafalaya River was rated 67 percent good and 33 percent poor.

Texas. Galveston Bay, Matagorda Bay, and Corpus Christi Bay are the three largest coastal embayments along the Texas coast. Sediment quality in in Galveston Bay rated as 50 percent good and 50 percent poor (Figure 3.2-4). Galveston Bay sediments were rated as very good for metal contaminants (Gonzalez, 2011). Sediment concentrations in the five areas within the bay that have been sampled regularly since the 1970s have improved for all metals, with the exception of mercury levels in the Houston shipping channel. The concentrations of organic contaminants associated with industrial processes, including polycyclic aromatic hydrocarbons and polychlorinated biphenyls, have also increased in the Houston shipping channel while sediments in other areas of the bay remain in very good condition. Farther south along the coastline, Matagorda Bay sediment quality was rated 67 percent good and 33 percent poor, and sediment quality in Corpus Christi Bay was rated 29 percent good and 71 percent poor.

3.2.2.1.1.5 Sediments in the Caribbean Region

The Caribbean Sea Large Marine Ecosystem includes offshore marine areas south and southeast of the Florida Keys. The majority of the Key West Range Complex is located within this ecosystem. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes located within each large marine ecosystem in the Study Area and Figure 3.0-5 for bathymetry in the Caribbean region. Sediment in the Straits of Florida consists of 50–95 percent carbonate sand, mud, and silt (Cronin, 1983). Sediment distribution in shallower areas (100 to 500 m) is influenced by tides and the Gulf of Mexico Loop Current; those at intermediate depths are influenced by the eastward-flowing Florida Current; and low-energy, westward-flowing currents dominate in deeper areas (greater than 800 m) (Brooks & Holmes, 1990). Sediments in Florida Bay are discussed above in the sections specific to Florida. Contamination of sediment and shellfish by organic and inorganic compounds was low in nearshore areas of Key West (Cantillo et al., 1997).

Sediment Quality in the Caribbean Region

Sediment quality in Puerto Rico was not assessed in the 2016 publication of the coastal condition assessment, but a 2012 publication, the National Coastal Condition Report IV, did assess sediment quality in island territories (U.S. Environmental Protection Agency, 2012b). Coastal sediment in Puerto Rico was rated 72 percent good, 2 percent fair, and 20 percent poor with 6 percent of data missing. Elevated levels of total organic carbon and contaminants in approximately 10 percent of coastal areas sample contributed to the poor ratings (U.S. Environmental Protection Agency, 2012b).

As discussed in Section 3.2.3.3 (Metals), Pait et al. (2010) surveyed areas at Vieques, Puerto Rico, that had been used extensively for Navy training and found generally low concentrations of metals in marine sediments. Coastal sediment in the U.S. Virgin Islands was rated 83 percent good and 17 percent poor. Elevated levels of total organic carbon and sediment toxicity were found at several sites across the islands of St. Croix, St. Thomas, and St. John (U.S. Environmental Protection Agency, 2012b). Whitall et al. (2015) sampled sediments in Fish and Coral bays on St. John Island in the U.S. Virgin Islands and analyzed the samples for metal contaminants, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and other chemical contaminants. Sediment contamination was low, with the exception of copper and chlordane concentrations which exceeded their Effects Range-Low thresholds.

3.2.2.1.2 Marine Debris, Military Materials, and Marine Sediments

In 2010, the Navy conducted hydrographic and geophysical surveys and sediment sampling with benthic imagery acquisitions off the coast of Florida so that sensitive underwater features could be avoided during construction of the Undersea Warfare Training Range. Approximately 700 square nautical miles (NM^2) of seabed across the shelf break in water depths ranging from 120 to 1,200 ft. were mapped, with image acquisition from a remotely operated vehicle. Although the study's intent was not to inventory debris on the seafloor, observations of debris were noted when observed. Trash was noted in multiple locations; however, only one instance of military materials was detected (a MK 58 Mod 1 marine location marker used for antisubmarine warfare, search and rescue operations, man-overboard markings, and as a target for practice bombing at sea) (U.S. Department of the Navy, 2010c). Evidence of decomposition and colonization of benthic organisms can be seen in Figure 3.2-5. Other studies in the

Atlantic Ocean inventoried marine debris (i.e., Law et al., 2010; Sheavly, 2007; U.S. Environmental Protection Agency, 2010), but did not differentiate military materials from trash from other sources.

Figure 3.2-5: Marine Marker Deposited on a Mound at 300 meter Depth

As suggested by the seafloor survey reported in Keller et al. (2010), of the 469 tows in which marine debris was recovered, none of the debris off of Washington, Oregon, or Northern California contained military expended material. Watters et al. (2010) conducted a visual survey of the seafloor that included a portion of the Navy's Southern California Range Complex as part of a 15-year quantitative assessment of marine debris on the seafloor off the California coast. Watters et al. (2010) found plastic was the most abundant material and, along with recreational monofilament fishing line, dominate in the debris (note that U.S. Navy vessels have a zero-plastic trash discharge policy and return all plastic waste to appropriate disposition sites on shore). There was only one item found that was potentially "military" in origin.

Because they are buoyant, many types of plastic items float and may travel thousands of miles in the ocean (U.S. Commission on Ocean Policy, 2004). Exceptions include heavy nets and ropes. Because many plastics remain in the water column, additional discussion of marine debris is provided in Section 3.0.3.3.6 (Ingestion Stressors). Although plastics are resistant to degradation, they do gradually break down into smaller particles due to sunlight (photolysis) and mechanical wear (Law et al., 2010). Thompson et al. (2004) found that microscopic particles were common in sediment at 18 beaches around the United Kingdom. They noted that such particles were ingested by small filter and deposit feeders, with unknown effects. The fate of plastics that sink beyond the continental shelf is largely unknown. However, analysis of debris in the center of an area near Bermuda with a high concentration of plastic debris on the surface showed no evidence of plastic as a substantial contributor to debris sinking at depths of 1,650–10,500 ft. (Law et al., 2010). Marine microbes and fungi are known to degrade biologically produced polyesters such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al., 1992). Marine microbes also degrade other synthetic polymers, although at slower rates (Shah et al., 2008).

3.2.2.1.3 Climate Change and Sediment

Aspects of climate change that influence sediment include increasing ocean acidity (pH), increasing sea surface water temperatures, and increasing storm activity. Breitbarth et al. (2010) referred to seawater temperature and pH as "master variables for chemical and biological processes," and noted that effects of changes on trace metal biogeochemistry "may be multifaceted and complex." Under more acidic conditions, metals tend to dissociate from particles to which they are bound in sediment, become more soluble, and potentially more available.

As noted in the beginning of this section, tropical storms can have significant impacts on the resuspension and distribution of bottom sediment (Wren & Leonard, 2005). However, no consensus appears to exist on whether climate change will generate more tropical storms or whether those storms will be more intense. If storm frequency and intensity increase, the additional disturbance of sediment may impact water quality in nearshore and coastal areas. A more detailed discussion of this issue is provided in Section 3.2.2.2 (Water Quality).

3.2.2.2 Water Quality

The current state of water quality in the Study Area, from nearshore areas to the open-ocean and deep sea bottom, is discussed below. Additional information on ocean currents in the Study Area is included in Section 3.0.2 (Ecological Characterization of the Study Area). Water quality screening criteria for contaminants in marine waters are shown in Table 3.2-4 and are referred to in assessing contaminant concentrations in the Atlantic and Gulf coast regions in the Study Area.

Table 3.2-4: Water Quality Screening Criteria for Metals and Organic Contaminants in Marine Waters

	Water Quality Guidelines – National Oceanic and Atmospheric Administration (ppb)	
Metal	***Acute***	***Chronic***
Antimony	1,500	500
Arsenic	69	36
Barium	1,000	200
Beryllium	1,500	100
Boron	N	1,200
Cadmium	40	8.8
Chromium III	10,300	27.4
Chromium IV	1,100	50
Cobalt	N	1
Copper	4.8	3.1
Iron	300	50
Lead	210	8.1
Mercury	1.8	0.94
Molybdenum	N	23
Nickel	74	8.2
Silver	0.95	N
Tin (tributyltin)	0.42	0.0074
Zinc	90	81
Organic Chemicals		
PAHs (Total)	300	N
PCBs (Sum)	0.033	0.03
DDT (Sum)	0.065	0.0005
Dieldrin	0.355	0.00095

Notes: Criteria are pH dependent. N = None provided.
PCBs = polychlorinated biphenyls, PAHs = polycyclic aromatic hydrocarbons, DDT = dichlorodiphenyltrichloroethane, ppb = parts per billion

3.2.2.2.1 Water Quality in the North Atlantic Region

The North Atlantic Region consists of the West Greenland Shelf, the Newfoundland-Labrador Shelf, and the Scotian Shelf Large Marine Ecosystems, as well as the Labrador Current Open Ocean Area. The area includes the coasts and offshore marine areas southwest of Greenland, east and northeast of Newfoundland and Labrador, and those surrounding Nova Scotia. Although there are no designated range complexes in this region, the area may be used for Navy training and testing activities.

Because of the low population densities and low levels of development, pollution from land-based sources is limited in the North Atlantic area (Aquarone & Adams, 2009a, 2009b; Aquarone et al., 2009). However, pollution is increasing from oil and gas development activities (Aquarone & Adams, 2009a, 2009b), and concern has been expressed regarding spills, discharges, and contaminants from marine vessels (Aquarone & Adams, 2009a).

3.2.2.2.2 Water Quality in the Northeast and Mid-Atlantic Region

The Northeast Region includes the Northeast and Virginia Capes Range Complexes and the Naval Undersea Warfare Center Division, Newport Testing Range. The testing range includes waters of Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, and Long Island Sound. The range complexes and testing range partially overlay the Northeast U.S. Continental Shelf Large Marine Ecosystem. See Figure 3.0-1 in Section 3.0 (Introduction) for the locations of these areas and Figure 3.0-4 for bathymetry in the northeast and mid-Atlantic region.

3.2.2.2.2.1 Open Ocean Water Quality

Sauer et al. (1989) surveyed the micro-surface layer and subsurface water at five open ocean sites off the Delaware-New Jersey shore for the presence of polychlorinated biphenyls and several chlorinated pesticides. Micro-surface layer samples collected contained polychlorinated biphenyl concentrations between less than 2 and 20 nanograms per liter (ng/L; 2–20 parts per trillion) and pesticide concentrations between less than 7 and 80 ng/L (7–80 parts per trillion). Subsurface water samples contained polychlorinated biphenyl concentrations between 0.007 and 0.17 ng/L (0.007–0.17 parts per trillion), and pesticide concentrations between 0.01 and 0.09 ng/L (0.01–0.09 parts per trillion). The screening criterion for acute concentrations of polychlorinated biphenyls is 0.033 parts per billion (equivalent to 33 parts per trillion), which is greater than the concentrations measured in the micro-surface layer measured by Sauer et al. (1989) (Table 3.2-4). The upper limit of the concentration of pesticides measured in the micro-surface layer exceeded the acute criterion for dichlorodiphenyltrichloroethane (DDT), but was well below the chronic level. The micro-surface layer represents the interface between the ocean and the atmosphere and is defined as the upper 1.0 mm of the water column (Wurl & Obbard, 2004). However the interface can serve as both a sink and a source of anthropogenic contaminants, including chlorinated hydrocarbons and heavy metals, and because of its physical and chemical properties, concentrations of chemicals can be several hundred times greater than in subsurface waters (Wurl & Obbard, 2004). Concentrations of polychlorinated biphenyls in the open ocean in the North Atlantic and Gulf of Mexico have been measures at less than 1 ng/L and open-ocean concentrations of dichlorodiphenyltrichloroethane (DDT) were measured as less than 0.2 ng/L (Wurl & Obbard, 2004).

In the western North Atlantic, Wallace et al. (1977) tested surface waters between Massachusetts and Bermuda. The authors reported that concentrations of metals measured in the study were well below the effects thresholds shown in Table 3.2-4.

In all cases except cadmium, the maximum values were found closest to the shore southeast of Cape Cod. The authors noted that suspended clay minerals and biologically produced particles are important concentrators of trace metals in the marine environment, and that the influence of river-borne suspended sediment extends approximately 1 mile offshore.

3.2.2.2.2.2 Nearshore Water Quality

States bordering the Northeast and Mid-Atlantic Region include Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and northeast North Carolina. Information regarding the current quality of marine waters in nearshore areas of these states is provided below.

The U.S. Environmental Protection Agency (2016) rated the waters along the northeast U.S. Atlantic coast as 44 percent good, 49 percent fair and 6 percent poor (Figure 3.2-6). Most of these poor sites were concentrated in a few estuarine systems, such as the New York/New Jersey Harbor, upper Delaware Bay, and upper Chesapeake Bay. The poor ratings were based on chlorophyll-*a* (a measure of turbidity) and low dissolved oxygen. Past and ongoing industrial activities also impact water quality (Aquarone & Adams, 2009c). Except where otherwise indicated, information provided below, including the data used in the water quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

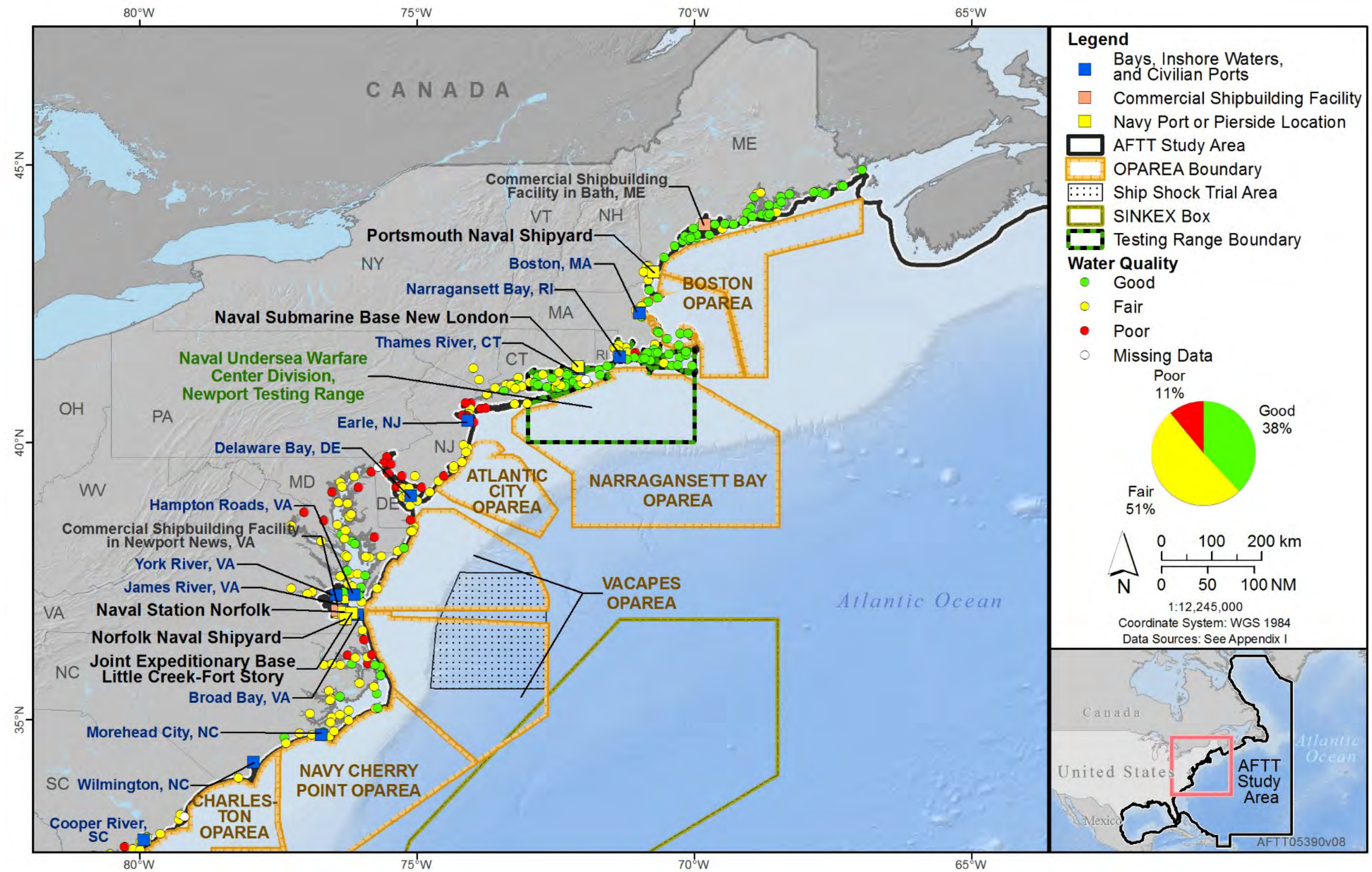
Maine. Water quality for all the estuaries and bays assessed in Maine is rated 88 percent good and 12 percent fair (Figure 3.2-6). All estuarine and marine waters in Maine have an advisory for the consumption of shellfish, specifically lobster tomalley, the green substance found inside the carapace that many consider to be a delicacy, due to the presence of polychlorinated biphenyls and dioxins, presumed to be from atmospheric deposition or prior industrial activity (U.S. Environmental Protection Agency, 2008b).

New Hampshire. Water quality for coastal waters, including estuaries and bays, assessed in New Hampshire was rated 33 percent good and 67 percent fair (Figure 3.2-6). The main concerns were over the contaminants dioxin, polychlorinated biphenyls, and mercury. Elevated levels of nutrients, pathogens, and turbidity were also noted as factors impacting water quality. Offshore and nearshore waters assessed in the surveys were also considered impaired based on similar concerns.

Massachusetts. Water quality for 82 percent of estuaries and bays assessed in Massachusetts is rated good, and 15 percent is rated fair, and 3 percent is poor, mostly due to the presence of pathogens (Figure 3.2-6). Toxic organics, high levels of nutrients, and low dissolved oxygen were also cited as contributors to fair and poor water quality.

Rhode Island. Water quality for 64 percent of estuaries and bays assessed in Rhode Island is rated good, and 36 percent is rated fair (Figure 3.2-6). The main contributors to impaired water quality included low dissolved oxygen levels, fecal coliform, and excess nutrients (i.e., nitrogen).

Connecticut. Water quality for 25 percent of estuaries and bays assessed in Connecticut is rated good, and 75 percent is rated fair (Figure 3.2-6). The main contributors to impaired water quality included low dissolved oxygen levels, eutrophication, and excess nutrients (i.e., nitrogen).



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

Figure 3.2-6: Water Quality Ratings for the Northeast and Mid-Atlantic Coast

New York. Water quality for 45 percent of estuaries and bays assessed in New York is rated good, 33 percent is rated fair, and 20 percent is rated poor (Figure 3.2-6). The main contaminant affecting water quality was polychlorinated biphenyls; other factors contributing to poor water quality included total coliform (bacteria in the water), low dissolved oxygen levels, elevated concentrations of cadmium, and excess nutrients (i.e., nitrogen). The most highly polluted areas were nearshore waters off of New York Harbor.

New Jersey. Water quality for 61 percent of estuaries and bays assessed in New Jersey is considered fair, and 39 percent is considered poor (Figure 3.2-6). The main contributors to impaired water quality included pesticides, polychlorinated biphenyls, low dissolved oxygen levels, and elevated concentrations of mercury. The report notes similar concerns for coastal and offshore marine waters.

Delaware. Water quality for all the estuaries and bays assessed in Delaware was rated 45 percent fair and 45 percent poor with 10 percent of data reported as missing (Figure 3.2-6). Excess nutrients (nitrogen and phosphorus), and pathogens were contributed approximately equally to reduced water quality. Poorest water quality was in the upper Delaware Bay downstream of Wilmington, the state's largest city.

Maryland. Water quality for 44 percent of the Maryland's coastal waters is rated good, 33 percent is rated fair, and 22 percent is rated poor (Figure 3.2-6). Wazniak et al. (2004) indicates that water quality conditions in Maryland's coastal bays range from generally degraded conditions within or close to tributaries to better conditions in the bay regions farther from shore. Excess nutrient levels are a contributor to most of the impaired waters. Tributaries generally show poor to very degraded water quality, primarily due to high nutrient inputs, while the open bays have good to excellent water quality. The Maryland Coastal Bays Program uses water quality indicators (e.g., chlorophyll-*a*, dissolved oxygen) as well as other metrics such as seagrass and hard clam densities to assess or grade the health of Maryland's coastal bays (Maryland Coastal Bays Program, 2015). The 2014 "report card" indicates that the collectively received a grade of C+, on a scale of A (good to very good) to F (very poor), on the program's index for characterizing the health of each coastal bay. Specifically for the water quality components of the report card, Chincoteague Bay (overall B-) scored good to very good for nitrogen, phosphorus, and chlorophyll-*a*, and dissolved oxygen was moderate. Assawoman Bay (C), scored as moderate for dissolved oxygen, nitrogen, and phosphorus (declined since 2013), and chlorophyll-*a* was very good (improved since 2013). Isle of Wight Bay (C) scored good to very good for nitrogen and chlorophyll-*a*, moderate for dissolved oxygen (a significant improvement), but poor to very poor for phosphorus. In Newport Bay (C-), chlorophyll-*a* was very good, and dissolved oxygen, nitrogen, and phosphorus were all moderate, an overall improvement since 2013.

Also, the northern bays are generally in poorer condition than the southern bays due to the extent of development and, to a lesser degree, the extent of flushing that occurs. Areas within the tidal portion of the Potomac River have been placed on the state 303(d) "impaired waters" list because of contamination by polychlorinated biphenyls (Interstate Commission on the Potomac River Basin, 2008).

Virginia. Water quality for 22 percent of coastal waters in Virginia is rated good, 74 percent is rated fair, and 4 percent is rated poor (Figure 3.2-6). The main issues involve polychlorinated biphenyls, noxious aquatic plants, and low dissolved oxygen. Water quality parameters are measured at over 4,000 stations in Virginia's coastal zone. Monitoring data show that 316 coastal water bodies are impaired (Virginia Department of Environmental Quality, 2001). Shellfish concerns are related to bacteria, and health advisories have been issued for fish consumption related to polychlorinated biphenyls and mercury (Virginia Department of Environmental Quality, 2016).

North Carolina. Water quality along the North Carolina coast was rated 25 percent good, 64 percent fair, and 11 percent poor. The main issues reported are mercury and selenium (at limited locations) in fish tissue. Impaired water quality was observed in the state's large coastal estuaries. In Albemarle Sound, 67 percent of survey sites reported either fair or poor water quality, and in Currituck Sound, 100 percent of sites rate poor for water quality. According to Mallin (2000), most estuaries in North Carolina exhibit low-to-moderate eutrophication. However, conditions in three estuaries—the Pamlico River, Neuse River, and New River—were rated as highly eutrophic based on frequency and extent of algal blooms, bottom-water hypoxia and anoxia, fish kills, and loss of submerged aquatic vegetation. Impairment is primarily the result of runoff from agricultural and urban areas that leads to excess nutrients and increased turbidity from algal blooms.

Chesapeake Bay. Bay water is listed as impaired under Section 303(d) of the federal Clean Water Act due to excess nutrients and sediment (U.S. Geological Survey, 2005). The most contaminated sites were concentrated at the northern end of the bay, where development is most intensive. Nutrient enrichment in the bay arises from agricultural and other nonpoint source runoff, and municipal and industrial wastewater treatment facilities (U.S. Army Corps of Engineers, 2009).

The Chesapeake Bay watershed includes portions of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia. In order to simplify the discussion and reduce repetition, water quality issues in the bay are not reviewed on a state-by-state basis because: (1) many of the water quality issues are common to most or all of these bordering states; and (2) Navy training and testing activities are limited to the extreme southeast portion of the bay and do not appreciably impact water quality in the bay as a whole.

3.2.2.2.3 Water Quality in the Southeast Region

The Southeast U.S. Continental Shelf Large Marine Ecosystem includes the Navy Cherry Point and Jacksonville Range Complexes, and the South Florida Ocean Measurement Facility Testing Range. See Figure 3.0-1 in Section 3.0 (Introduction) for the locations of these areas and Figure 3.0-5 for bathymetry in the Southeast region.

3.2.2.2.3.1 Open Ocean Water Quality

Of the large marine ecosystems in the Study Area, the southeast is judged to be in the best ecological condition (Aquarone et al., 2009). Sauer et al. (1989) surveyed the micro-surface layer and subsurface water at five open ocean sites between Cape Hatteras, North Carolina and Florida for the presence of polychlorinated biphenyls and several chlorinated pesticides. Micro-surface layer samples collected contained polychlorinated biphenyl concentrations between less than 0.5 and 1.5 ng/L and pesticide concentrations between less than 0.5 and 1.0 ng/L. Subsurface water samples contained polychlorinated biphenyl concentrations between 0.003 and 0.424 ng/L and pesticide concentrations between 0.013 and 0.1 ng/L. No concentrations exceeded the acute concentration criteria for either contaminant. The concentration of pesticides exceeded the chronic concentration criterion for dichlorodiphenyltrichloroethane (DDT) in the micro-surface layer, but not in the subsurface layers (Table 3.2-4).

3.2.2.2.3.2 Nearshore Water Quality

States bordering the Southeast U.S. Continental Shelf Large Marine Ecosystem include southeast North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida. Information regarding the current quality of marine waters in the nearshore areas of these states is provided below (Figure 3.2-7). The USEPA (2016) rated 21 percent good, 69 percent of the waters along the southeast coast as fair, and 9 percent of the sites sampled rated poor. Except where otherwise indicated, information provided below, including the data used in the water quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

North Carolina. Refer to the Section 3.2.2.2.2.2 (Nearshore Water Quality) for the Northeast and Mid-Atlantic states.

South Carolina. For South Carolina, water quality for 86 percent of coastal waters was rated fair, 10 percent is rated poor, and 5 percent is reported as missing (Figure 3.2-7). Estuaries in South Carolina exhibit low or moderate eutrophication (Mallin et al., 2000). Poor water quality is primarily linked to high turbidity levels, which reduce water clarity in coastal and estuarine areas.

Georgia. Water quality along Georgia's coast was rated 57 percent fair and 43 percent poor based on five indicators: dissolved oxygen, dissolved inorganic nitrogen, dissolved inorganic phosphorus, turbidity as measured by chlorophyll-*a*, and water clarity (Figure 3.2-7). Eighty percent of the state's estuaries rated fair, 18 percent rated poor, and 2 percent rated good. Increasing eutrophication and decreasing water clarity were noted as concerns (Sheldon & Alber, 2010).

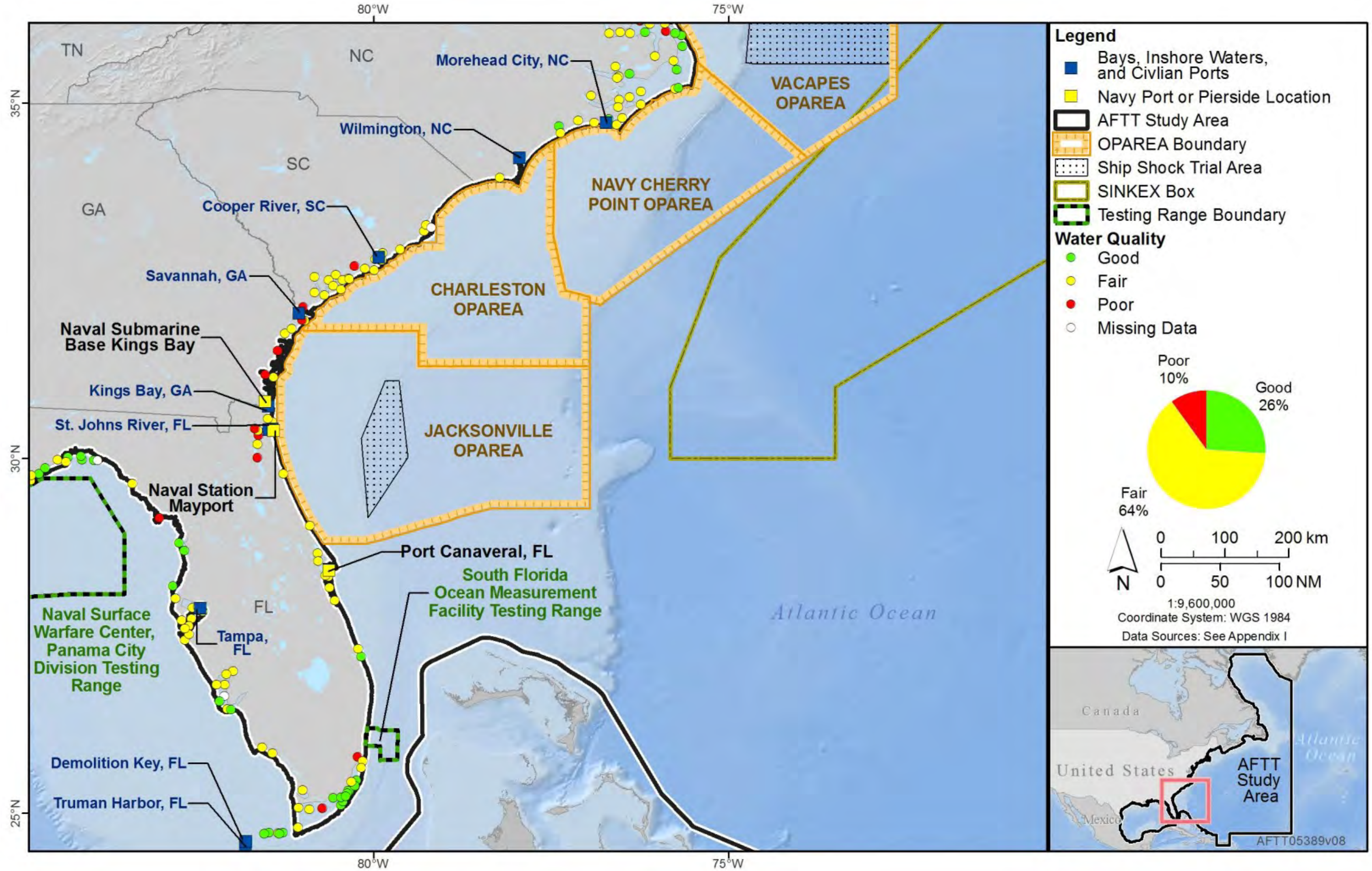
Florida. Water quality along Florida's Atlantic coast is rated 13 percent good, 70 percent fair, and 17 percent poor (Figure 3.2-7). Most of the state's estuaries and coastal waters are considered impaired because of mercury in fish tissue, low dissolved oxygen, high turbidity as measured by chlorophyll-*a* concentrations, fecal coliform, and bacteria in shellfish. Harmful algal blooms and nutrient enrichment are of increasing concern (Florida Department of Environmental Protection, 2010).

3.2.2.2.4 Water Quality in the Gulf of Mexico Region

The Gulf of Mexico Region includes the Gulf of Mexico Range Complex, which consists of four Operating Areas: Panama City, Pensacola, New Orleans, and Corpus Christi. Also within the Gulf of Mexico Large Marine Ecosystem are the Naval Surface Warfare Center, Panama City Division Testing Range (Florida) and a portion of the Key West Range Complex. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within each large marine ecosystem and Figure 3.0-6 for bathymetry in the Gulf of Mexico region.

3.2.2.2.4.1 Open Ocean Water Quality

Unlike the other areas, no open ocean areas are specifically designated for the Gulf of Mexico. However, Sauer et al. (1989) surveyed the micro-surface layer and subsurface water at six sites in the west central part of the Gulf of Mexico for the presence of polychlorinated biphenyls and several chlorinated pesticides. Micro-surface layer samples collected contained polychlorinated biphenyl concentrations between less than 0.2 and 1.0 ng/L and pesticide concentrations between less than 0.1 and 0.5 ng/L. Subsurface water samples contained polychlorinated biphenyl concentrations between 0.0006 and 0.0024 ng/L and pesticide concentrations between 0.0002 and 1.46 ng/L. No concentrations exceeded the acute concentration criteria for either contaminant. The highest concentration of pesticides equaled the chronic concentration criterion for dichlorodiphenyltrichloroethane (DDT) in the micro-surface layer, and exceeded the chronic concentration criterion in the subsurface layers (Table 3.2-4).



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

Figure 3.2-7: Water Quality Ratings for the Southeast Coast

3.2.2.2.4.2 Nearshore Water Quality

States bordering the Gulf of Mexico Region include the Gulf coast of Florida, Alabama, Mississippi, Louisiana, and Texas. Information regarding the current quality of marine waters in the nearshore areas of these states is provided. The USEPA (2016) rated the gulf waters as 16 percent good, 58 percent fair, and 24 percent poor. Various combinations of all the water quality indicators were responsible for poor site conditions. Onshore development, oil and gas extraction, and excess nutrients are the main sources of stress on the Gulf of Mexico (Heileman & Rabalais, 2008). Except where otherwise indicated, information provided below, including the data used in the water quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

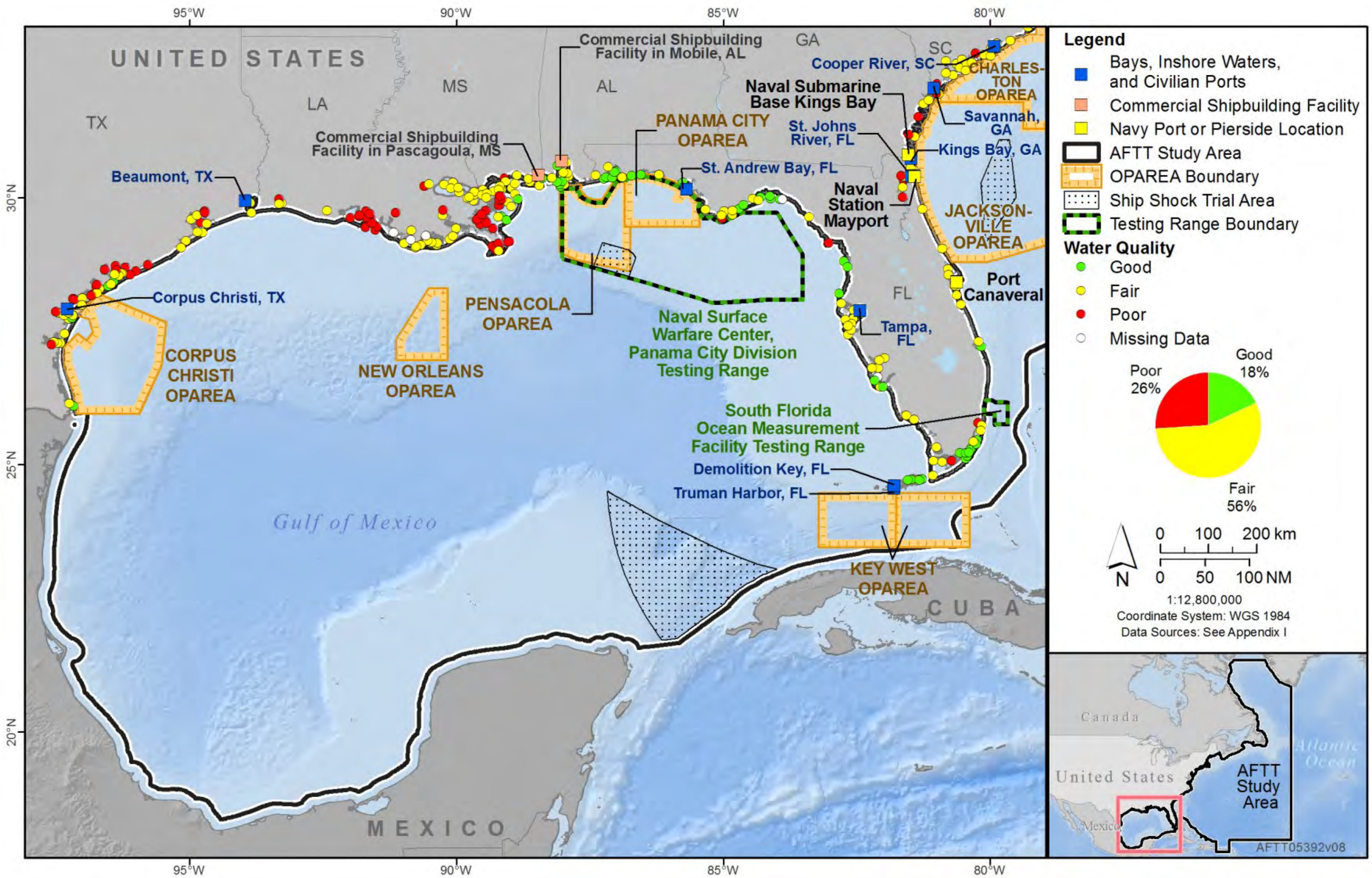
Florida. Water quality along Florida's Gulf coast was rated 47 percent good, 47 percent fair, and 4 percent poor with 3 percent of data reported as missing (Figure 3.2-8). Mercury in fish tissue, bacteria in shellfish, low dissolved oxygen, high turbidity as measured by chlorophyll-*a*, and fecal coliform are also concerns along the Gulf coast.

Lewis et al. (2001) studied the impacts of urbanization on three areas in Pensacola Bay. Although total metal concentrations varied widely, copper and zinc were most commonly detected in surface waters. Average levels for copper exceeded both the chronic (3.1 µg/L) and acute (4.8 µg/L) exposure levels established to protect marine life. Cadmium, chromium, and nickel were detected in fewer samples but, where detected, concentrations exceeded chronic exposure levels. Concentrations of most chlorinated pesticides, polycyclic aromatic hydrocarbons, and all polychlorinated biphenyls were below the limits of detection. The most commonly detected pesticides were diazinon (0.03–0.22 µg/L) and atrazine (0.03–0.30 µg/L). The authors noted that some pesticides occasionally exceeded the recommended maximum surface water concentration of 0.004 µg/L and that total polycyclic aromatic hydrocarbon concentrations at some sites exceeded the recommended annual average of less than or equal to 0.031 µg/L, but these occasions were "uncommon." Petroleum hydrocarbons were detected in surface water collected from several sites, but most commonly in Bayou Grande, where the average concentrations ranged from 1.1 to 8.9 µg/L.

Alabama. Water quality for the coastal waters assessed for Alabama was rated 35 percent good and 65 percent fair (Figure 3.2-8). Pathogens (e.g., fecal bacteria) and mercury in fish tissue contributed to reduced water quality.

Mississippi. Of the 23 mi. of coastal Mississippi shoreline assessed, 10 percent rated good, 80 percent rated fair, and 10 percent rated poor (Figure 3.2-8). The main issue was pathogens (fecal bacteria). Sampling along the coast indicated degraded water clarity and high phosphorus levels contributed to poor water quality.

Louisiana. Water quality for the coastal waters assessed for Louisiana was rated 3 percent good, 47 percent fair, and 46 percent poor with 3 percent of data reported as missing (Figure 3.2-8). Clark and Goolsby (2000) studied herbicide concentrations in the Mississippi River at Baton Rouge between 1991 and 1997. Peak herbicide concentrations generally followed peak discharges in late winter or early spring. Herbicides and their metabolites were detected in more than half of the samples (e.g., alachlor, atrazine, metolachlor, deethylatrazine, and cyanazine). No compound exceeded 5 µg/L, and the total herbicide concentration did not exceed 10 µg/L. None of the average annual concentrations of the herbicides examined in that study exceeded maximum contaminant levels or the health advisory levels established at that time.



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

Figure 3.2-8: Water Quality Ratings for the Gulf of Mexico Coast

Texas. Water quality for the coastal waters in Texas was rated 11 percent good, 55 percent fair, and 34 percent poor (Figure 3.2-8). In nearshore waters and estuaries, the main concerns were with bacteria (in oyster waters) and low dissolved oxygen. Farther offshore, impairment was associated with bacteria concentrations and mercury in fish tissue.

3.2.2.2.5 Water Quality in the Caribbean Region

The Caribbean Region includes offshore marine areas south and southeast of the Florida Keys. The majority of the Key West Range Complex is located within this ecosystem. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within each large marine ecosystem and Figure 3.0-5 for bathymetry in the Caribbean region. These marine waters are clear and poor in nutrients (Heileman & Mahon, 2008). Water quality in nearshore waters of Puerto Rico was not assessed in the 2016 publication of the coastal condition assessment, but a 2012 publication, the National Coastal Condition Report IV, did assess sediment quality in island territories (U.S. Environmental Protection Agency, 2012b). Coastal water quality in Puerto Rico was rated 50 percent good, 40 percent fair, and 10 percent poor. Poor water clarity ratings in combination with elevated dissolved inorganic phosphorous levels or chlorophyll-*a* concentrations at individual sites resulted in the poor ratings (U.S. Environmental Protection Agency, 2012b). Several of the poor water quality ratings were in coastal areas near San Juan, the most populous city on the island. Coastal water quality in the U.S. Virgin Islands was rated 60 percent good, 34 percent fair, and 0 percent poor with 6 percent of data reported as missing (U.S. Environmental Protection Agency, 2012b).

Specific information regarding water quality in the Key West Range Complex could not be located. As with other coastal areas, nearshore water quality is mostly influenced by onshore activities and development, plus the discharge of solid waste and wastewater from commercial and cruise vessels (Heileman & Mahon, 2008; Lapointe et al., 1994).

3.2.2.2.6 Marine Debris and Water Quality

The National Marine Debris Monitoring Program developed three categories of marine debris for its study of the extent of man-made materials in the oceans: land-based, ocean-based, and general (i.e., origin unspecified) (Sheavly, 2007). Land-based debris may blow in on the wind, be washed in with storm water, arise from recreational use of coastal areas, and be generated by extreme weather such as hurricanes. Ocean-based sources of marine debris include commercial shipping and fishing, private boating, offshore mining and extraction, and legal and illegal dumping at sea. Ocean current patterns, weather and tides, and proximity to urban centers, industrial and recreational areas, shipping lanes, and fishing grounds influence the types and amount of debris found (Sheavly, 2010). These materials are concentrated at the surface and in the near-surface water column.

According to Sheavly (2010), land-based sources account for about half of marine debris, and ocean- and waterway-based sources contribute another 18 percent. Galgani et al. (2015) confirm that the majority of marine debris originates from land. Land-based debris included syringes, condoms, metal beverage cans, motor oil containers, balloons, six-pack rings, straws, tampon applicators, and cotton swabs as well as other items. Ocean-based debris included gloves, plastic sheets, light bulbs and tubes, oil and gas containers, pipe-thread protectors, nets, traps and pots, fishing line, light sticks, rope, salt bags, fish baskets, cruise line logo items, and floats and buoys. Plastics, generally referring to petroleum-based, manmade materials, make up the vast majority of marine debris (Galgani et al., 2015; Law et al., 2014). Microscopic plastic fragments enter the marine environment from use as scrubbers in hand cleaning and other cosmetic products, abrasive beads for cleaning ships, and deterioration of macroscopic plastics

(Teuten et al., 2007). Microplastic beads commonly used in cosmetic products such as facial scrubs and other exfoliants are not broken down in wastewater treatment facilities and are largely not filtered out of the waste stream before they are flushed into the marine environment in enormous quantities (Chang, 2015; Napper et al., 2015). These microbeads are found worldwide in marine sediments, persist in the marine environment, and accumulate up the food chain (Cole & Galloway, 2015).

Plastics may serve as vehicles for transport of various pollutants, whether by binding them from seawater or from the constituents of the plastics themselves. Mato et al. (2001) noted that polypropylene resin pellets (precursors to certain manufactured plastics) collected from sites in Japan contained polychlorinated biphenyls, dichlorodiphenyldichloroethylene (a breakdown product of DDT), and the persistent organic pollutant nonylphenol (a precursor to certain detergents). Polychlorinated biphenyls and dichlorodiphenyldichloroethylene were adsorbed from seawater. The original source of nonylphenol was less clear; it may have originated from the pellets themselves or may have been adsorbed from the seawater and accumulated on the surface of plastics. Microbeads have also been shown to adsorb hydrophobic chemical contaminants, such as DDT, from seawater, allowing for the accumulation and transport of these often toxic chemicals to widely dispersed areas of the oceans. While the impacts on the marine ecosystem are largely unknown, some examples illustrating potential widespread impacts have been discussed. For example, it has been suggested that white and blue microplastic beads, common in many exfoliants, resemble plankton and may be mistakenly ingested by plankton-feeding fishes, which rely on visual cues to find prey (Napper et al., 2015; Wright et al., 2013). The long-term effects on the environment from the proliferation of microbeads and other microplastics are still being researched. Since there is no way of effectively removing microplastics from the marine environment, and given that plastics are highly resistant to degradation, it is likely that the quantity of microplastics in the marine environment will only continue to increase, and therefore the likelihood of environmental impacts can only increase (Napper et al., 2015). The only way to reduce long-term impacts is to reduce or eliminate the use of microplastics, a course of action that is gaining recognition (Chang, 2015).

Marine debris findings in the Study Area (Sheavly, 2007) are provided in Table 3.2-5. In a recent survey of marine debris in the North Atlantic, 62 percent of all net tows contained detectable amounts of plastic debris (Law et al., 2010). The highest concentrations were observed between 22° and 38° north latitude (roughly south of Florida to Maine). Tows closest to land, such as along the Florida coast and in the Gulf of Maine, found relatively small amounts of plastic.

Because of their buoyancy, many types of plastic items float and may travel thousands of miles in the ocean (U.S. Commission on Ocean Policy, 2004). Exceptions include heavy nets and ropes. Although plastics are resistant to degradation, they do gradually break down into smaller particles due to sunlight and mechanical wear (Law et al., 2010). A study by Teuten et al. (2007) indicated that the water-borne phenanthrene (a type of polycyclic aromatic hydrocarbon) adhered preferentially to small pieces of plastic ingested by a bottom-dwelling marine lugworm and incorporated into its tissue. Marine microbes and fungi are known to degrade biologically produced polyesters, such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al., 1992). Marine microbes also degrade other synthetic polymers, although at slower rates (Shah et al., 2008).

Table 3.2-5: Percent Marine Debris by Source in Atlantic Fleet Training and Testing Study Area

Sheavly Study Area	*Locations within Study Area*	*Land-Based (%)*[1]	*Ocean-Based (%)*[1]	*General (%)*[1]
Region 1 (Provincetown, Massachusetts to Canadian border)	Northeast Range Complexes	28	42	30
Region 2 (Cape Cod, Massachusetts to Beaufort, North Carolina)	Northeast and Virginia Capes Range Complexes; Naval Undersea Warfare Center Division, Newport Testing Range	63	7	30
Region 3 (Morehead City, North Carolina to Port Everglades, Florida)	Navy Cherry Point and Jacksonville Range Complexes; South Florida Ocean Measurement Facility	41	14	44
Regions 4 & 5 (Port Everglades, Florida to Mexican border)	Gulf of Mexico and Key West Range Complexes; Naval Surface Warfare Center, Panama City Division Testing Range	48	16	36

[1]Numbers may not sum due to rounding.
Notes: % = percent

Annex V of the International Convention for the Prevention of Pollution from Ships prohibits the discharge of plastic waste from vessels at sea, and the U.S. Act to Prevent Pollution from Ships brought U.S. public vessels in alignment with the international convention. The National Defense Authorization Act of 1996 specifically directed the Navy to install plastic waste processors aboard the surface fleet. The U.S. Navy's plastics waste processors compress and melt shipboard-generated plastic waste into dense, sanitary disks of compressed plastics that can be stored over long at-sea deployments. The plastic waste items include lightly contaminated food containers as well as clean plastics and other materials that may be combined with, or contain, plastic components that cannot be processed in the normal solid waste stream. The plastic waste disks are offloaded for proper disposal once a ship comes into port. The plastic compression technology enables Navy ships to operate at sea over long time periods without discharging plastics into the oceans.

3.2.2.2.7 Climate Change and Water Quality

According to the U.S. Global Change Research Program, the rise in ocean temperature over the last century will continue into the future, with continued and perhaps increasing impacts on ocean circulation, marine chemistry, and marine ecosystems. Because the ocean currently absorbs about a quarter of human-produced carbon dioxide emissions, increasing carbon dioxide absorption will increase acidification of ocean waters. This in turn will alter the distribution, abundance, and productivity of many marine species and affect water quality in coastal and open ocean waters (Melillo et al., 2014).

Key findings of the 2014 National Climate Assessment that may pertain to waters in the AFTT Study Area:

- Local sea level rise (amplified by coastal subsidence) is greater than the global average for the Chesapeake Bay.
- Sea level rise and related flooding and erosion threaten coastal homes, infrastructure, and commercial development, including ports.

- Ecosystems of the southeast are vulnerable to loss from relative sea level rise, especially tidal marshes and swamps.
- The incidence of harmful algal blooms is expected to increase with climate change, as are health problems previously uncommon in the region.
- The number of land-falling tropical storms may decline in the gulf, reducing important rainfall, while there has been an increase in the frequency of tropical storms and major hurricanes in the North Atlantic.
- The Florida Keys, South Florida, and coastal Louisiana are particularly vulnerable to additional sea level rise and saltwater intrusion.

The Paris Agreement builds upon the Convention and — for the first time — brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

At the 2015 Paris Climate Conference, 195 parties to the United Nations Framework Convention on Climate Change adopted the first-ever universal, global climate agreement, referred to as the Paris Agreement in which all countries voluntarily set and committed to individual carbon reduction goals. The Agreement marks the latest step in the evolution of the United Nations climate change initiative and builds on the work undertaken under the Convention over the past several decades.

The Paris Agreement seeks to accelerate and intensify the actions and investment needed for sustaining low carbon emissions into the future. Its central aim is to strengthen the global response to the threat of climate change and greenhouse gas emissions by limiting a global temperature rise over this century to no more than 2 degrees Celsius above pre-industrial levels. The Paris Agreement also includes a commitment to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

The United States signed the Paris Agreement on April 22, 2016, and on September 3, 2016, the United States accepted ratification of the Agreement. However, on June 1, 2017, the President announced that the United States would withdraw from the Paris Agreement. The official withdrawal requires a formal process, which will take nearly four years to complete. According to the rules of the Paris Agreement, a nation wishing to withdraw must first submit a document to the United Nations specifying its intent to withdraw. The submission of the document is permitted only after three years have passed since the agreement entered into force, in this case November 4, 2016. The earliest the United States can submit its written notice is November 4, 2019, and the earliest the United States could complete the withdrawal process is November 4, 2020.

3.2.3 Environmental Consequences

This section evaluates how and to what degree the training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) may impact sediments and water quality in the Study Area. Tables 2.6-1 through 2.6-4 present proposed training and testing activity locations for each alternative, including number of events conducted annually and over a five-year period for alternatives 1 and 2. Each water quality stressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities. Potential impacts could be from:

- releasing materials into the water that subsequently disperse, react with seawater, or may dissolve over time;

- depositing materials on the ocean bottom and any subsequent interactions with sediments or the accumulation of such materials over time;
- depositing materials or substances on the ocean bottom and any subsequent interaction with the water column; and
- depositing materials on the ocean bottom and any subsequent disturbance of those sediments or their resuspension in the water column.

These potential impacts may result from four stressors: (1) explosives and explosives byproducts, (2) metals, (3) chemicals other than explosives, and (4) other materials. The term "stressor" is used because materials in these four categories may directly impact sediments and water quality by altering their physical and chemical characteristics.

The area of analysis for sediments and water quality includes the estuaries, nearshore areas, and the open ocean (including the seafloor) in the Study Area. The environmental fate of explosives, explosives byproducts, metals, and other materials depends on environmental factors, geochemical conditions, and various mechanisms that transport the constituents in the environment. Some natural transport mechanisms, such as advection by currents, dispersion, dissolution (dissolving), precipitation by chemical reaction, and adsorption (the adhesion of a chemical constituent onto the surface of a particle in the environment [e.g., clay]) reduce concentrations in water and redistribute constituents between the water and sediments. Other processes, such as biodegradation, may change or destroy the explosive compounds but would not affect metals. For this analysis, potential impacts on sediments and water quality from military expended materials that come to rest in sediment at a given distance from shore are assumed to be similar whether off the Atlantic coast or the Gulf of Mexico.

3.2.3.1 Explosives and Explosives Byproducts

Explosives may be introduced into the seawater and sediments by the Proposed Action. The explosive fillers contained within the munitions used during training and testing activities and their degradation products can enter the environment through high-order detonations (i.e., the munition functions as intended and the vast majority of explosives are consumed), low-order detonations (i.e., the munition partially functions with only a portion of the explosives consumed), or unexploded munitions (i.e., the munition fails to detonate and explosives remain in the casing). In the case of a successful detonation, only a small or residual amount of explosives may enter the marine environment (U.S. Environmental Protection Agency, 2012a). A low-order detonation would result in some residual explosives and some unconsumed explosives remaining in the munitions casing entering the water. In the case of unexploded munitions, the explosives contained in the munition would not be consumed and would remain encased within the munition as it enters the marine environment. The munitions casing may corrode or rupture over time and release explosives into the sediments and water column.

The behavior of explosives and explosives byproducts in marine environments and the extent to which those constituents of explosives have adverse impacts are influenced by a number of processes, including the ease with which the explosive dissolves in a liquid such as water (solubility), the degree to which explosives are attracted to other materials in the water (e.g., clay-sized particles and organic matter, sorption), and the tendency of the explosives to evaporate (volatilization). These characteristics, in turn, influence the extent to which the material is subject to biotic (biological) and abiotic (physical and chemical) transformation and degradation (Pennington & Brannon, 2002). The solubility of various explosives is provided in Table 3.2-6. In the table, higher values indicate greater solubility. For example, high melting explosive is virtually insoluble in water. Table salt, which dissolves easily in water, is included in the table for comparison.

Table 3.2-6: Water Solubility of Common Explosives and Explosive Degradation Products

Compound	*Water Solubility[1] (mg/L at 20 °C)*
Table salt (sodium chloride)[2]	357,000
Ammonium perchlorate (O)	249,000
Picric acid (E)	12,820
Nitrobenzene (D)	1,900
Dinitrobenzene (E)	500
Trinitrobenzene (E)	335
Dinitrotoluene (D)	160
Trinitrotoluene (TNT) (E)	130
Tetryl (E)	51
Pentaerythritol tetranitrate (E)	43
Royal Demolition Explosive (E)	38
High Melting Explosive (E)	7

[1]Units are milligrams per liter (mg/l) at 20 degrees Celsius.
[2]Table salt is not an explosive degradation product
Notes: D = explosive degradation product, E = explosive, O = oxidizer additive; TNT = trinitrotoluene
Source: U.S. Department of the Navy (2008a)

According to Walker et al. (2006), trinitrotoluene (TNT), royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems. The authors noted that productivity in marine and estuarine systems is largely controlled by the limited availability of nitrogen. Because nitrogen is a key component of explosives, they are attractive as substrates for marine bacteria that metabolize other naturally occurring organic matter, such as polycyclic aromatic hydrocarbons. Juhasz and Naidu (2007) also noted that microbes use explosives as sources of carbon and energy.

Carr and Nipper (2003) indicated that conversion of trinitrotoluene (TNT) to carbon dioxide, methane, and nitrates in coastal sediments (a process referred to as mineralization) occurred at rates that were typical for naturally occurring compounds such as phenanthrene, fluoranthene, toluene, and naphthalene. They noted that transformation of 2, 6-dinitrotoluene and picric acid by organisms in sediments is dependent on temperature and type of sediment (e.g., finer-grained). Pavlostathis and Jackson (2002) reported that the marine microalgae *Anabaena* spp. were highly efficient at the removal and metabolism of trinitrotoluene (TNT) in a continuous flow experiment. Nipper et al. (2002) noted that irreversible binding to sediments and biodegradation of 2, 6-dinitrotoluene, tetryl, and picric acid occurred in fine-grained sediments high in organic carbon resulting in lower concentrations of the contaminants. Cruz-Uribe et al. (2007) noted that three species of marine macroalgae metabolize trinitrotoluene (TNT) to 2-amino-4,6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene, and speculate that "the ability of marine macroalgae to metabolize trinitrotoluene (TNT) is widespread, if not generic." The studies cited above indicate that trinitrotoluene (TNT) and its constituent products can be removed from the environment by naturally occurring biological processes in sediments, reducing sediment toxicity from these chemical contaminants.

Singh et al. (2009) indicated that biodegradation of royal demolition explosive and high melting explosive occurs with oxygen (aerobic) and without oxygen (anoxic or anaerobic), but that they were more easily degraded under anaerobic conditions. Crocker et al. (2006) indicated that the mechanisms of high melting explosive and royal demolition explosive biodegradation are similar, but that high melting explosive degrades more slowly. Singh et al. (2009) noted that royal demolition explosive and high melting explosive are biodegraded under a variety of anaerobic conditions by specific microbial species and by mixtures of such species. Zhao et al. (2004a); (2004b) found that biodegradation of royal demolition explosive and high melting explosive occurs in cold marine sediments.

According to Singh et al. (2009), typical end products of the degradation of royal demolition explosive include nitrite, nitrous oxide, nitrogen, ammonia, formaldehyde, formic acid, and carbon dioxide. Crocker et al. (2006) stated that many of the primary and secondary intermediate compounds from biodegradation of royal demolition explosive and high melting explosive are unstable in water and spontaneously decompose. Thus, these explosives are degraded by a combination of biotic and abiotic reactions. Formaldehyde is subsequently metabolized to formic acid, methanol, carbon dioxide, or methane by various microorganisms (Crocker et al., 2006).

A series of research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016; University of Hawaii, 2010) and an intensively used live fire range in the Mariana Islands (Smith & Marx, 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life.

On a localized scale, research at World War II munitions ocean disposal sites in Hawaii investigated nearby sediments, seawater, or marine life to determine if released constituents from the munitions (including explosive components and metals) could be detected. Comparisons were made between disposal site samples and "clean" reference sites. The samples analyzed showed no confirmed detection for explosives.

Investigations by Kelley et al. (2016) and Koide et al. (2016) found that intact munitions (i.e., ones that failed to detonate or non-explosive practice munitions) residing in or on soft sediments habitats provided hard substrate similar to other disposed objects or "artificial reefs" that attracted "hard substrate species," which would not have otherwise colonized the area. Sampling these species revealed that there was no bioaccumulation of munitions-related chemicals in the species (Koide et al., 2016).

On a broader scale, the island of Farallon De Medinilla (in the Mariana Islands) has been used as a target area for both explosive and non-explosive munitions since 1971. Between 1997 and 2012, the Navy has conducted 14 underwater scientific surveys around the island, providing a consistent, long-term investigation of a single site where munitions have been used regularly (Smith & Marx, 2016). Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, bony fishes, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the physical or biological resources had been adversely impacted to a significant degree by the training activities (Smith & Marx, 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 Dahlgren have included rounds from small-caliber guns up to the Navy's largest (16 inch [in.] guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (U.S. Department of the Navy, 2013b). Results from the assessment indicate that munitions expended at Dahlgren have not contributed significant concentrations of explosive materials or explosives byproducts 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 manmade sources (U.S. Department of the Navy, 2013a).

Underwater detonations for training purposes have been conducted approximately five miles off the coast of Virginia Beach, Virginia using demolition charges on non-explosive underwater mine shapes. Training activities at the underwater ordnance disposal site began after World War II, but became a regular occurrence in 1968. The primary munitions used at the site are the M112 demolition charge (consisting of 91 percent hexahydro-1,3,5-trinitro-1,3,5-triazine [i.e., royal demolition explosive]), M456 detonation cord (containing pentaerythritoltetranitre [also referred to as "PETN"]), and the M700 time blasting fuse. Based on the analysis reported in U.S. Department of the Navy (2012), accumulation of explosive byproducts was not expected to occur in sediments at the site, because of the infrequent nature of the detonations, the small amounts of chemicals of concern produced by the detonations, and the large attenuation capacities of the affected water body (i.e., nearshore areas of the Atlantic Ocean).

In summary, multiple investigations since 2007 involving survey and sampling of World War II munition dump sites off Oahu Hawaii and other locations, have found the following: (1) chemicals and degradation products from underwater munitions "do not pose a risk to human health or to fauna living in direct contact with munitions," (2) metals measured in sediment samples next to World War II munitions are lower than naturally occurring marine levels and "do not cause a significant impact on the environment," and (3) sediment is not a significant sink of chemicals released by degradation of the explosive components in munitions (Edwards et al., 2016).

Bauer and Kendall (2010) reported on the collection and analysis of sediment samples that were tested for the presence of explosive compounds at Vieques, Puerto Rico following the cessation of Navy training activities on the island. Sediment samples were analyzed for the parent compounds, 2,4,6-trinitrotoluene (TNT), high melting explosive, royal demolition explosive, and Tetryl (2,4,6-trinitrophenyl-n-methylnitramine), and for degradation products including 1,3,5-trinitrobenzene, 2,4-dinitrotoluene, and 2,6-dinitrotoluene. Of the 78 samples collected, 14 showed signs of explosive compounds and required a more in depth analysis to confirm the presence of explosive compounds or degradation products. The analysis revealed that explosives were either not present or were present at such low concentrations that they could not be measured.

The concentration of explosive munitions and any associated explosives byproducts at any single location in the Study Area would be a small fraction of the totals that have accumulated over decades at World War II era dump sites and military ranges. Based on findings from much more intensively used locations, effects on sediments from the use of explosive munitions during training and testing activities would be negligible by comparison. As a result, explosives by-products and unexploded munitions would have no meaningful effect on sediments.

Most explosive material is consumed in an explosion, so the vast majority of intact explosive material entering the marine environment would be encased in munitions that failed to detonate. Failure rates are not available for the vast majority of munitions used in the Proposed Action; however, based on the data that are available Table 3.2-7, a 5-percent munitions failure rate was selected as a reasonable average rate to estimate the failure rates for all munitions used in the Proposed Action. Based on the available data, low-order detonation rates for all munitions are assumed to be at least an order of magnitude less than the failure rates and are not considered in the analysis.

Table 3.2-7: Failure and Low-Order Detonation Rates of Military Munitions

Munitions	*Failure Rate (Percent)*	*Low-Order Detonation Rate (Percent)*
Guns/artillery	4.68	0.16
Hand grenades	1.78	n/a
Explosive munitions	3.37	0.09
Rockets	3.84	n/a
Submunitions	8.23	n/a

Source: MacDonald and Mendez (2005)
Note: n/a = not available

Most activities involving explosives and explosives byproducts would be conducted more than 3 NM offshore in each range complex and testing range. Activities in these areas (3–200 NM) would be subject to federal sediment and water quality standards and guidelines.

Explosives are also used in nearshore areas (low tide line to 3 NM) specifically designated for mine countermeasure and mine neutralization activities. These activities would be subject to state sediment and water quality standards and guidelines.

For explosives byproducts, “local” refers to the water column in the vicinity of the underwater detonation. For unconsumed explosives, “local” refers to the area of potential impact from explosives in a zone of sediment about 6 ft. in diameter around the unconsumed explosive where it comes to rest on the seafloor.

3.2.3.1.1 Impacts from Explosives and Explosives Byproducts under Alternative 1

3.2.3.1.1.1 Impacts from Explosives and Explosives Byproducts under Alternative 1 for Training Activities

The distribution of explosives used in training activities is not uniform throughout the Study Area. Approximately 30 percent of the explosives used annually during training activities would be used in the Jacksonville Range Complex and 60 percent would be used in the Virginia Capes Range Complex. The remaining 10 percent would be distributed in other locations of the Study Area. Of all explosive munitions used during training activities, approximately 55 percent of explosives used in the Jacksonville Range Complex and 60 percent of explosives used in the Virginia Capes Range Complex would have a net explosive weight between 0.1 and 0.25 pounds (lb.) per munition. Training activities are further described in Chapter 2 (Description of Proposed Action and Alternatives) and listed in Table 2.3-2 and Table 2.6-1.

The highest concentrations of munitions residues results from munitions failures (i.e., low-order detonations). As a general rule, between 10,000 and 100,000 high-order detonations deposit the same mass of explosives residue as one low-order detonation of the same munition (U.S. Environmental Protection Agency, 2012a) Therefore, an estimate of the amount of explosives material and byproducts from an explosion that would be introduced into the environment is based solely on the failure rate for each type of munition, discounting the negligible contribution from munitions that successfully detonate. The military does not track failure rates for all munitions. The available data typically report failure rates ranging from less than 2 percent up to 10 percent (Table 3.2-7). For the purpose of estimating the amount of explosives and explosives byproducts entering the marine environment, a 5-percent failure rate is applied to all types of munitions used during training activities. The amount of explosive materials is estimated by multiplying the failure rate by the number of explosive munitions and the net explosive weight of each munition used during training activities.

To better organize and facilitate the analysis of different types of explosive munitions, each munition using in training and testing activities was grouped into a series of source classification bins, or source bins (see Section 3.0.3.3.2, Explosive Stressors). Each source bin is defined by a range of net explosive weights (e.g., bin E3 has a range of 0.5 to 2.5 lb. net explosive weight). To estimate the amount of explosive materials entering the marine environment, the average net explosive weight was calculated for each source bin. For example, for bin E1 (0.1 to 0.25 lb. net explosive weight) under Alternative 1:

> Explosives = 0.05 (Failure Rate) x 1,600 (Munitions in Bin E1) x 0.175 lb. (Average Net Explosive Weight) = 14 lb.

One other factor needs to be considered when estimating the amount of explosives entering the marine environment in munitions that fail to detonate. The net explosive weight of an explosive munition is based on the equivalent amount of trinitrotoluene (TNT) that would be required to generate the desired amount of energy upon detonation. Most modern munitions no longer use trinitrotoluene (TNT) as the primary explosive material. Other more powerful and stable explosives such as royal demolition explosive are used in a greater number of explosive munitions. Because royal demolition explosive is more powerful than trinitrotoluene (TNT), a lesser amount of royal demolition explosive is needed to generate the equivalent explosion using trinitrotoluene (TNT). The equivalency factors for royal demolition explosive is 1.60, meaning that, to generate an explosion equivalent to 1 kilogram (kg) of trinitrotoluene (TNT) only 0.625 kg of royal demolition explosive is needed. Revising the equation above to incorporate the trinitrotoluene (TNT) equivalency factor:

> Explosives = 0.05 (Failure Rate) x 1,600 (Munitions in Bin E1) x 0.175 lb. (Average Net Explosive Weight) x 0.625 (equivalency factor) = 8.75 lb.

Using this approach, and considering all training activities in the AFTT Study Area, up to approximately 4,000 lb. of explosive material could enter the environment annually in the form of munitions that failed to detonate. Approximately 40 percent, or 1,600 lb. of explosives, would come from munitions in the E5 bin. These munitions are used at least 3 NM and often more than 12 NM from shore, which diminishes any potential impact on nearshore sediments and water quality. Water depth increases with distance from shore, such that munitions residing on the seafloor at depths greater than 250 m would be in a low light, low temperature environment slowing the corrosion of munitions casings and that degradation of any exposed explosives. Larger projectiles (e.g., missiles, rockets, bombs) that fail to detonate would enter the water at a high rate of speed, and, depending on the type of seafloor substrate (e.g., soft sediments), can become imbedded in the seafloor. Munitions that are buried partially or completely beneath sediments may remain intact for decades where geochemical conditions (e.g., low dissolved oxygen) inhibit corrosion of the metal casing. Studies conducted at several Navy ranges where explosives have been used for decades indicate that explosives constituents are released into the aquatic environment over long periods of time and do not result in water or sediment toxicity (Briggs et al., 2016; U.S. Department of the Navy, 2010a, 2010b, 2013a).

The overarching conclusions from the Hawaii Undersea Military Munitions Assessment project is that degrading munitions at the disposal site do not pose a risk to human health or to the fauna living in direct contact with the degrading munitions (Edwards et al., 2016). During a comprehensive survey of the site, explosive materials were detected in sediments at only two locations and the concentrations were low. Concentrations of metals introduced into sediments and the water column from deteriorating munitions casings were below screening levels for the marine environment, and the authors concluded that the metals are not impacting the environment.

Data supporting these conclusions were collected from World War II era munitions disposal sites characterized by relatively high concentrations of munitions. Munitions used in the proposed training activities would be widely dispersed by comparison, resulting in lower concentrations of munitions that failed to detonate and lower concentrations of residual explosives and explosives byproducts than reported in Edwards et al. (2016). Based on this analysis, impacts on sediments and water quality are expected to be minimal.

In the event a munition fails to detonate, the explosives contained within the intact munition would remain isolated from the water column and sediments. Based on analyses of munitions disposal sites, explosives would only leach from the munitions casing slowly, over decades, once the munitions casing corrodes and is breached, exposing the explosives to seawater or sediments (Briggs et al., 2016). Small amounts of explosives may leach into sediments and the adjacent water column. In the event the munition fails to detonate but the casing is nevertheless breached upon impact, explosives may enter the water column as the breached munitions sinks to the seafloor. Analysis from munitions disposal sites indicates that munitions constituents and degradation products are only detected at measurable levels in sediments within a few feet of a degrading munition. Many constituents released into the water column would be expected to dissolve (refer to Table 3.2-6 for water solubility) and disperse with ocean currents and not concentrate at levels that would result in water toxicity. Explosives released into sediments from a partially buried munition may persist in sediments or degrade slowly over time if the explosive material or its constituents are not soluble in seawater (e.g., royal demolition explosive). In deep water (greater than 250 m), benthic habitats, bottom temperatures are near freezing, and dissolved oxygen levels are low (or event anoxic) in sediments only a few inches below the water column-seafloor interface. These physical conditions inhibit degradation and dispersion of the explosives and constituents beyond an isolated area adjacent to the munition. Based on this analysis, impacts on sediments and water quality are expected to be minimal.

The sinking exercise activity is likely to result in the highest concentration of munitions of any proposed training or testing activity. During each sinking exercise, for example, an estimated 216 explosive munitions would be expended, 93 percent of which would consist of large-caliber projectiles in the E5 bin. Approximately 178 lb. of explosive materials could be released per sinking exercise if the munitions utilized failed to detonate. For the purpose of this example, the area encompassing the sinking exercise activity is estimated to be approximately 2 NM^2. Thus, during each sinking exercise, approximately 108 munitions would be used per NM^2 and 89 lb. of explosive material per NM^2 would sink to the ocean floor encased within munitions that failed to detonate. During an actual sinking exercise munitions are directed at the target vessel, which occupies an area much smaller than 2 NM^2, and it is likely that a failure rate of less than 5 percent would occur for this type of activity. All Sinking Exercises are conducted at least 50 NM from shore in waters at least 6,000 ft. deep. Based on these conditions and the results of the analysis of munitions degradation rates in the studies described above, which occurred at shallower depths and closer to shore, adverse effects on seafloor sediments and water quality are not expected even in areas where the concentration of munitions is likely to be relatively high.

3.2.3.1.1.2 Impacts from Explosives and Explosives Byproducts under Alternative 1 for Testing Activities

The distribution of explosives used in testing activities is not uniform throughout the Study Area. Approximately 30 percent of the explosives used annually during testing activities would be used in the Jacksonville Range Complex and 50 percent would be used in the Virginia Capes Range Complex. The remaining 20 percent would be distributed in other locations of the Study Area. Of all explosive munitions used during testing activities, approximately 70 percent are in the E1 bin (0.1 to 0.25 lb. per munition). Excluding munitions in the E1 bin, which primarily consist of medium-caliber projectiles, approximately 50 percent of other munitions are in the E3 bin (0.5 to 2.5 lb. net explosive weight) and 30 percent are in the E5 bin (5 to 10 lb.).

As described for training activities in Section 3.2.3.1.1.1 (Impacts from Explosives and Explosives Byproducts under Alternative 1 for Training Activities), over 98 percent of explosives byproducts introduced into the environment would result from the failure of a munition to detonate, because little to no explosive material remains after a successful detonation. The amount of residual explosives materials resulting from testing activities is estimated in the same way it was estimated for training activities: by multiplying the failure rate by the number of explosive munitions and the average net explosive weight for the bin in which each explosive munitions is classified.

The Ship Shock Trial activity conducted by Naval Sea Systems Command is the only activity that would use explosives in the E16 and E17 bins. In the unlikely event munitions in either of these two bins failed to detonate during a Ship Shock Trial activity, additional attempts would be made to detonate the explosive. If an explosive cannot be detonated or disarmed and recovered, then to safeguard human life, the explosive will be disposed of at sea in accordance with established Ammunition and Explosives Safety Afloat requirements.

Over the past 29 years, there have been approximately 11 Ship Shock Trials involving a combined total of between 33 and 40 separate detonations. Of those detonations, only two munitions did not detonate as planned. One of those munitions was ultimately detonated after the activity was completed, and the second was disposed of at sea in a known and marked area designated for unexploded ordnance and munitions disposal. Based on three decades of Ship Shock Trials, a detonation failure rate of 2.5 to 3 percent could be expected. The proposed Large Ship Shock Trial activity would occur once over a 5-year period and use up to 64 munitions in the E17 bin, and the Small Ship Shock Trial activity would occur up to three times over a 5-year period and use up to 64 munitions in the E16 bin (see Table 2.6-3 in Chapter 2 [Description of Proposed Action and Alternatives]). Applying a failure rate of 3 percent results in approximately two failed detonations in the E17 bin and two in the E16 bin. Considering that only one munition in one of the two bins remained intact in the marine environment after conducting 11 Ship Shock Trails over nearly 30 years, the probability of a detonation failure occurring during no more than 4 Ship Shock Trials over a 5-year period is expected to be very low. Therefore, munitions in the E16 and E17 bins were excluded from estimates of the amount of explosives entering the marine environment in the event of a detonation failure.

For testing activities in the AFTT Study Area, up to approximately 2,400 lb. of explosive material would enter the environment annually in munitions that failed to detonate. Approximately 44 percent, 1,150 lb., are from munitions in the E10 bin (250 to 500 lb.), which are used at least 3 NM and often more than 12 NM from shore, and 15 percent are from munitions failures in the E5 bin. The testing activities Air to Surface Missile Test and Missile and Rocket Testing use all munitions in the E10 bin. For more information on those activities, refer to Appendix A (Navy Activity Descriptions).

In the event a munition fails to detonate, the explosives would remain mostly intact and contained within the munitions casing, which is composed mostly of iron with smaller quantities of other metals. Explosive materials would only leach from the casing slowly, over years, as the casing corrodes and degrades in the deepwater (greater than 250 m) environment. Once exposed to the environment, explosives materials are quickly broken down into constituent materials (Briggs et al., 2016). Ocean currents would quickly disperse constituents entrained into the water column. Chemical constituents that settle onto sediments in the immediate vicinity of the munition are likely to persist in the environment due to a combination of low water solubility, the products of hydrolysis forming a coating that prevents further decomposition, and near freezing temperatures at deepwater sites that typically inhibit chemical dissolution (Briggs et al., 2016).

Larger projectiles used in testing activities that fail to detonate would enter the water at a high rate of speed and may become imbedded in soft sediments, depending on water depth and the composition of seafloor substrate. Munitions buried partially or completely beneath sediments may remain intact for decades in places where geochemical conditions (e.g., low dissolved oxygen) inhibit corrosion of the metal casing. Studies conducted at several Navy ranges where explosives have been used for decades indicate that explosives constituents are released into the aquatic environment over long periods of time and do not result in water or sediment toxicity (Briggs et al., 2016; U.S. Department of the Navy, 2010a, 2010b, 2013a). Based on the results from studies of underwater munitions disposal sites and water ranges, impacts on sediments and water quality are expected to be minimal and localized.

The overarching conclusions from the Hawaii Undersea Military Munitions Assessment project is that degrading munitions at the disposal site do not pose a risk to human health or to the fauna living in direct contact with the degrading munitions (Edwards et al., 2016). During a comprehensive survey of the site, explosive materials were detected in sediments at only two locations and the concentrations were low. Concentrations of metals introduced into sediments and the water column from deteriorating munitions casings were below screening levels for the marine environment, and the authors concluded that the metals are not impacting the environment.

Data supporting these conclusions were collected from World War II era munitions disposal sites characterized by relatively high concentrations of munitions. Munitions used in the proposed testing activities would be widely dispersed by comparison, resulting in lower concentrations of munitions that failed to detonate and lower concentrations of residual explosives and explosives byproducts than reported in Edwards et al. (2016). Based on this analysis, impacts on sediments and water quality are expected to be minimal.

3.2.3.1.2 Impacts from Explosives and Explosives Byproducts under Alternative 2

3.2.3.1.2.1 Impacts from Explosives and Explosives Byproducts under Alternative 2 for Training Activities

Under Alternative 2, the number of explosive munitions used during training activities would be the same as under Alternative 1. Therefore, the impacts of underwater explosives and explosives byproducts would be the same as described under Alternative 1.

3.2.3.1.2.2 Impacts from Explosives and Explosives Byproducts under Alternative 2 for Testing Activities

Under Alternative 2, the number of explosive munitions used during the Airborne Mine Neutralization Test conducted by Naval Air Systems Command would increase over Alternative 1. The activity, which is conducted at the NSWC Panama City Training Range and the Virginia Capes Range Complex would use

10 E11 mines (5 in each location) and 10 E4 neutralizers (5 in each location). However, the amount of explosives entering the environment would remain essentially the same, because mines that failed to detonate as planned would be detonated by other means and would not be permitted to remain in the environment as intact munitions. Based on a 5-percent failure rate, only 2 to 3 neutralizers would be expected to fail over five years, resulting in no more than 15 lb. of explosives deposited on the seafloor in intact munitions over five years. This is a less than one-tenth of 1 percent of the total amount of explosives released under Alternative 1 and is negligible. The amount of explosives byproducts would increase; however, for the reasons described above in Section 3.2.3.1.1.1 (Impacts from Explosives and Explosives Byproducts under Alternative 1 for Training Activities), the amount of additional explosives byproducts entering the environment would be undetectable and impacts would therefore be the same as under Alternative 1.

3.2.3.1.3 Impacts from Explosives and Explosives Byproducts under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no potential for impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of explosives would decrease the amounts of related chemical constituents in marine waters and sediments in the Study Area. The effect, however, would likely not be measurable due to the rapid dissolution and dispersion of explosives and explosives byproducts in the water column and the slow, sometimes decades-long corrosion of undetonated munitions on the seafloor. Explosives and explosives byproducts released into sediments from degrading munitions would be decomposed and disperse, or, if persistent in sediments, would only be expected at higher concentrations in sediments within a few feet of the munition.

3.2.3.2 Chemicals Other Than Explosives

Under the Proposed Action, chemicals other than explosives are associated with the following military expended materials: (1) solid-fuel propellants in missiles and rockets; (2) Otto Fuel II torpedo propellant and combustion byproducts; (3) polychlorinated biphenyls in target vessels used during sinking exercises; (4) other chemicals associated with munitions; and (5) chemicals that simulate chemical warfare agents, referred to as “chemical simulants.”

Hazardous air pollutants from explosives and explosives byproducts are discussed in Section 3.1 (Air Quality). Explosives and explosives byproducts are discussed in Section 3.2.3.1 (Explosives and Explosives Byproducts). Fuels onboard manned aircraft and vessels are not reviewed, nor are fuel-loading activities, refueling at sea, onboard operations, or maintenance activities reviewed, because normal operation and maintenance of Navy equipment is not part of the Proposed Action.

The largest chemical constituent of missiles is solid propellant. Solid propellant contains both the fuel and the oxidizer, a source of oxygen needed for combustion. An extended-range Standard Missile-2 typically contains 1,822 lb. of solid propellant. Ammonium perchlorate is an oxidizing agent used in most modern solid-propellant formulas (Chaturvedi & Dave, 2015). It normally accounts for 50 to 85 percent of the propellant by weight. Ammonium dinitramide may also be used as an oxidizing agent. Aluminum powder as a fuel additive ranges from 5 to 22 percent by weight of solid propellant; it is added to increase missile range and payload capacity. The high-explosives high melting explosive (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and royal demolition explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine) may be added, although they usually comprise less than 30 percent of the propellant by weight.

Many of the constituents used in propellants are also commonly used for commercial purposes but require additional processing to achieve certain properties necessary for rocket and missile propulsion. (Missile Technology Control Regime, 1996).

The U.S. Environmental Protection Agency issued a paper characterizing the munitions constituents accumulated at over 30 military sites around the United States and Canada where explosives and propellants have been used (U.S. Environmental Protection Agency, 2012b). The sites assessed in the paper were all land-based ranges; however, the results are useful for analyzing similar activities conducted at sea. The paper noted that perchlorate was generally not detected at anti-tank ranges and that perchlorate is so soluble in water and mobile in soil that surface accumulation apparently does not occur. The paper includes a case study that estimates the amount of residual perchlorate deposited from a rocket fired at a test track. The rocket propellant contained 68 lb. of ammonium perchlorate. Samples were collected both behind the firing point and along the test track before and after the rocked was fired. No differences in perchlorate concentrations in soils were detected at any location before or after the firing, and all measurements recorded perchlorate concentrations of less than 1 microgram per kilogram (μg/kg). That case study concluded that 99.997 percent of perchlorate is consumed by the rocket motor (U.S. Environmental Protection Agency, 2012b). Jenkins et al. (2008) found similar results from an air-launched AIM-7 missile, a missile used by the Navy and similar to missiles used in the Proposed Action. These studies, and others cited in each paper, demonstrate that the motors used in rockets and missiles are highly efficient at burning propellant fuels, leaving only trace amounts often at undetectable levels in the environment.

Several torpedoes (e.g., MK-54) use Otto Fuel II as a liquid propellant. Otto Fuel II is composed of primarily three synthetic substances: Propylene glycol dinitrate and nitro-diphenylamine (76 percent), dibutyl sebacate (22 percent) and 2-nitrodiphenylamine as a stabilizer (2 percent). Propylene glycol dinitrate, which is a liquid, is the explosive component of Otto Fuel II. Dibutyl sebacate, also known as sebacic acid, is also a liquid. It is used commercially to make plastics, many of which are used for packaging food, and to enhance flavor in foods such as ice cream, candy, baked goods, and nonalcoholic drinks. The third component, 2-nitrodiphenylamine, is a solid substance used to control the combustion of the propylene glycol dinitrate (U.S. Health and Human Services 1995). Combustion byproducts of Otto Fuel II include nitrous oxides, carbon monoxide, carbon dioxide, hydrogen, nitrogen, methane, ammonia, and hydrogen cyanide. During normal venting of excess pressure or upon failure of the torpedo's buoyancy bag, the following constituents are discharged: carbon dioxide, water, hydrogen, nitrogen, carbon monoxide, methane, ammonia, hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate (Arai & Chino, 2012).

Target vessels are only used during sinking exercises, which occur infrequently. Polychlorinated biphenyls are a concern because they are present in certain solid materials (e.g., insulation, wires, felts, and rubber gaskets) on vessels used as targets for sinking exercises. These vessels are selected from a list of Navy-approved vessels that have been cleaned in accordance with USEPA guidelines (U.S. Environmental Protection Agency, 2014). By rule, a sinking exercise must be conducted at least 50 NM offshore and in water at least 6,000 ft. deep (40 CFR part 229.2).

The USEPA estimates that as much as 100 lb. of polychlorinated biphenyls remain onboard sunken target vessels. The USEPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.) (U.S. Environmental Protection Agency, 2014). Under a 2014 agreement with the USEPA, the Navy will not likely use aircraft carriers or submarines as the targets for a sinking exercise (U.S. Environmental

Protection Agency, 2014). Based on these considerations, polychlorinated biphenyls will not be considered further.

Table 3.2-8 lists the chemical constituents produced in the combustion of propellants and fuels, as described above, and lists constituents remaining after the detonations of non-munitions, such as spotting charges and tracers. Not all of the listed chemical constituents in propellant and Otto Fuel II would be used in combination; some are substitutes that would replace another chemical in the list, depending on the type of propellant used. For example, ammonium perchlorate is the preferred oxidizer in propellant, but ammonium dinitramide could act as the oxidizer in some propellants. These constituents are in addition to the explosives contained in munitions, which were discussed in Section 3.2.3.1 (Explosives and Explosives Byproducts).

The environmental fate of Otto Fuel II and its components is largely unknown. Neither the fuel mixture nor its three main components are particularly volatile or soluble in water; however, when mixed with water propylene glycol dinitrate forms a volatile mixture, making evaporation an important fate process (U.S. Department of Health and Human Services, 1995). The compound 2-Nitrodiphenylamine may precipitate from water or be taken up by particulates. Dibutyl sebacate is rapidly biodegraded. Neither propylene glycol dinitrate nor 2-nitrodiphenylamine are readily biodegradable, but both of these chemicals break down when exposed to ultraviolet light (Powell et al., 1998).

Table 3.2-8: Constituents in Munitions Other Than Explosives

Munitions Component	***Constituent***
Pyrotechnics Tracers Spotting Charges	Barium chromate Potassium perchlorate Chlorides Phosphorus Titanium compounds
Oxidizers	Lead (II) oxide
Propellant (rockets and missiles)	High melting explosive Royal demolition explosive Hydroxyl-terminated polybutadiene Carboxyl-terminated polybutadiene Polybutadiene-acrylic acid-acrylonitrile Triphenyl bismuth Nitrate esters Nitrated plasticizers Polybutadiene-acrylic acid polymer Elastomeric polyesters Polyethers Nitrocellulose plasticized with nitroglycerine 2-nitrodiphenylamine N-methyl-4-nitroaniline Hydrazine

Lead azide, titanium compounds, perchlorates, barium chromate, and fulminate of mercury are not natural constituents of seawater. Lead oxide is a rare, naturally occurring mineral. It is one of several lead compounds that form films on lead objects in the marine environment (Agency for Toxic Substances and Disease Registry, 2007). Metals are discussed in more detail in Section 3.2.3.3 (Metals).

Because chemical and biological warfare agents remain a security threat, the Department of Defense uses relatively harmless compounds (chemical simulants) as substitutes for chemical and biological warfare agents to test equipment intended to detect their presence. Chemical and biological agent detectors monitor for the presence of chemical and biological warfare agents and protect military personnel and civilians from the threat of exposure to these agents. The simulants trigger a response by sensors in the detection equipment without irritating or injuring personnel involved in testing detectors.

Table 3.2-8: Constituents in Munitions Other Than Explosives (continued)

Munitions Component	*Constituent*
Otto Fuel II (torpedoes)	Propylene glycol dinitrate and Nitro-diphenylamine (76 percent by weight) dibutyl sebacate (22 percent by weight 2-nitrodiphenylamine (2 percent by weight) Combustion products (nitrous oxides, carbon monoxide, carbon dioxide, hydrogen, nitrogen, methane, ammonia, hydrogen cyanide) Venting or buoyancy bag failure (hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate)
Chemical Simulants	Navy Chemical Agent Simulant 82 glacial acetic acid triethyl phosphate sulfur hexafluoride 1,1,1,2 tetrafluoroethane 1,1-difluoroethane
Delay Elements	Barium chromate Potassium perchlorate Lead chromate
Fuses	Potassium perchlorate
Detonators	Fulminate of mercury Potassium perchlorate
Primers	Lead azide

Navy Chemical Agent Simulant 82 (commonly referred to as NCAS-82), glacial acetic acid, triethyl phosphate, sulfur hexafluoride, 1,1,1,2 tetrafluoroethane (a refrigerant commonly known as R134), and 1,1-difluoroethane (a refrigerant commonly known as R-152a) are also referred to as gaseous simulants and can be released in smaller quantities in conjunction with glacial acetic acid or triethyl phosphate releases. The types of biological simulants that may be used include spore-forming bacteria, non-spore-forming bacteria, ovalbumin, bacteriophage MS2, and *Aspergillus niger*. The simulants are generally dispersed by hand at the detector or by aircraft as a fine mist or aerosol. The exposure of military personnel or the public to even small amounts of real warfare agents, such as nerve or blistering agents, or harmful biological organisms, such as anthrax, is potentially harmful and is illegal in most countries, including the United States. Furthermore, their use, including for the testing of detection equipment, is banned by international agreement.

Simulants must have one or more characteristic of a real chemical or biological agents—size, density, or aerosol behavior—to effectively mimic the agent. Simulants must also pose a minimal risk to human health and the environment to be used safely in outdoor tests. Simulants are selected using the following criteria: (1) safety to humans and the environment, and (2) the ability to trigger a response by sensors used in the detection equipment. Simulants must be relatively benign (e.g., low toxicity or effects potential) from a human health, safety, and environmental perspective. Exposure levels during testing activities should be well below concentrations associated with any adverse human health or environmental effects. The degradation products of simulants must also be harmless. Given these criteria for choosing simulants for use in testing activities, it is reasonable to conclude that simulants would have no impact on sediments and water quality in the Study Area. Simulants are not analyzed further in this section.

3.2.3.2.1 Impacts from Chemicals Other Than Explosives under Alternative 1

3.2.3.2.1.1 Impacts from Chemicals Other Than Explosives under Alternative 1 for Training Activities

The distribution of munitions that use chemicals other than explosives is not uniform throughout the Study Area. The largest quantities of chemicals would be derived from the use of propellants and fuels in munitions, specifically rockets, missiles, and torpedoes. Approximately 48 percent of these munitions, used annually during training activities would be used in the Jacksonville Range Complex and 43 percent would be used in the Virginia Capes Range Complex. The remaining 9 percent would be distributed in other locations of the Study Area. Of all of these munitions, approximately 94 percent are rockets (expending the byproducts of propellant combustion), and 4 percent are missiles. Approximately 100 torpedoes using Otto Fuel II would be used annually. The propellant used by rockets and missiles is typically consumed prior to impact at the water's surface even if the munition fails to detonate upon impact, leaving little residual propellant to enter the water. By contrast, torpedo fuel is consumed underwater and all combustion products enter the marine environment.

For properly functioning munitions, chemical, physical, or biological changes in sediments or water quality would not be detectable. Impacts would be minimal for the following reasons: (1) the size of the area in which expended materials would be distributed is large; (2) most propellant combustion byproducts are benign, while those of concern would be diluted to below detectable levels within a short time; (3) most propellants are consumed during normal operations; (4) most byproducts of Otto Fuel II combustion are naturally occurring chemicals, and most torpedoes are recovered after use, such that any fuel that is not consumed would be recovered along with the torpedo, limiting any direct exposure of sediments and water to Otto Fuel II; (5) the failure rate of munitions using propellants and other combustible materials is low; and (6) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

3.2.3.2.1.2 Impacts from Chemicals Other Than Explosives under Alternative 1 for Testing Activities

The distribution of munitions that use chemicals other than explosives is not uniform throughout the Study Area. Approximately 28 percent of these munitions used annually during testing activities would be used in the Virginia Capes Range Complex, 25 percent would be used in the Jacksonville Range Complex, 23 percent would be used in the Navy Cherry Point Range Complex, and 23 percent would be used in the Northeast Range Complexes. Of all of these munitions used during testing activities, approximately 90 percent are biological chemical simulants, which, as noted above, are benign and would have no impact on sediments and water quality. Excluding biological simulants, 38 percent of munitions using chemicals other than explosives are rockets (expending the byproducts of propellant combustion), 30 percent are missiles, and 30 percent are torpedoes (using Otto Fuel II).

For properly functioning munitions, chemical, physical, or biological changes in sediments or water quality would not be detectable. Impacts would be minimal for the following reasons: (1) the size of the area in which expended materials would be distributed is large; (2) most propellant combustion byproducts are benign, while those of concern would be diluted to below detectable levels within a short time; (3) most propellants are consumed during normal operations; (4) most byproducts of Otto Fuel II combustion are naturally occurring chemicals, and most torpedoes are recovered after use, such that any fuel that is not consumed would be recovered along with the torpedo, limiting any direct exposure of sediments and water to Otto Fuel II; (5) the failure rate of munitions using propellants and other combustible materials is low; and (6) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

3.2.3.2.2 Impacts from Chemicals Other Than Explosives under Alternative 2

3.2.3.2.2.1 Impacts from Chemicals Other Than Explosives under Alternative 2 for Training Activities

Under Alternative 2, the number of expended munitions that use propellants (missiles and rockets) and Otto Fuel II (torpedoes) would be the same as described under Alternative 1. The amounts of other expended materials which could release chemicals into the marine environment would be similar to the amounts under Alternative 1. Therefore, the release of chemicals derived from propellants and fuels would have the same environmental impacts as described under Alternative 1.

3.2.3.2.2.2 Impacts from Chemicals Other Than Explosives under Alternative 2 for Testing Activities

The number of munitions that use propellants (rockets and missiles) and Otto Fuel II (torpedoes) annually would increase under Alternative 2. Over a five-year period, an additional 400 rockets, 130 missiles, and 300 torpedoes would be used during testing activities. Because rocket and missile motors are over 99 percent efficient at burning propellant, no additional measurable amounts of propellant or combustion products would enter the water column. As described in Section 3.2.3.2 (Chemicals Other than Explosives), most byproducts of Otto Fuel II combustion are naturally occurring chemicals. Most practice torpedoes are recovered after use, such that any fuel that is not consumed would be recovered along with the torpedo limiting any direct exposure of sediments and water to Otto Fuel II. Therefore, the use of torpedoes would not result in the accumulation of byproducts of Otto Fuel II in water or sediments. The amounts of other expended materials which could release chemicals into the marine environment would be similar to the amounts under Alternative 1. Therefore, the release of chemicals derived from propellants and fuels would have the same environmental impacts as described under Alternative 1.

3.2.3.2.3 Impacts from Chemicals Other Than Explosives under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no potential for impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of chemicals other than explosives would decrease the amounts of these chemicals and their constituents in marine waters and sediments in the Study Area. The effect, however, would likely not be measurable due to the highly efficient use of propellants and fuels by motors used in rockets and missiles, resulting in often undetectable trace amounts of propellants expended into the environment. Perchlorates, which make up a large percentage of rocket and missile propellants, are also water soluble and would dissolve and be dispersed in surface waters and would not accumulate in marine sediments. Similarly, it is unlikely that Otto Fuel II used in torpedoes would be exposed to sediments or water, and most combustion byproducts of Otto Fuel II occur naturally in the marine environment.

3.2.3.3 Metals

Anthropogenic sources of metals include the processing of industrial ores (e.g., iron ore), production of chemicals, fertilizers used in agriculture, the marine industry (e.g., anti-fouling anti-corrosion paints), runoff from urban and suburban sprawl, dredge spoil disposal, exhaust from automotive transportation, atmospheric deposition, and industrial emissions (Järup, 2003). Metals are introduced into nearshore and offshore marine waters and sediments by the Proposed Action. Because of the physical and chemical reactions that occur with metals in marine systems, many metals will precipitate out of seawater and settle in solid form on the seafloor where they can concentrate in sediments. Thus, metal contaminants in sediments pose a greater environmental concern than metals in the water column.

Military expended materials such as steel bomb bodies or fins, missile casings, small arms projectiles, and naval gun projectiles may contain small percentages (less than 1 percent by weight) of lead, manganese, phosphorus, sulfur, copper, nickel, tungsten, chromium, molybdenum, vanadium, boron, selenium, columbium, or titanium. Small-caliber projectiles are composed of steel with small amounts of aluminum and copper and brass casings that are 70 percent copper and 30 percent zinc. Medium- and large-caliber projectiles are composed of steel, brass, copper, tungsten, and other metals. The 20-mm cannon shells used in close-in weapons systems are composed mostly of tungsten alloy. Some projectiles have lead cores (U.S. Department of the Navy, 2008b). Torpedo guidance wire is composed of copper and cadmium coated with plastic (U.S. Department of the Navy, 2008a). Sonobuoy components include batteries and battery electrodes, lead solder, copper wire, and lead used for ballast. Thermal batteries in sonobuoys are contained in an airtight, sealed and welded stainless steel case that is 0.03–0.1 in. thick and resistant to the battery electrolytes (U.S. Department of the Navy, 2008a). Rockets are usually composed of steel and steel alloys, although composite cases made of glass, carbon, or Kevlar fiber are also used (Missile Technology Control Regime, 1996).

Non-explosive practice munitions consist of ammunition and components that contain no explosive material, and may include (1) ammunition and components that have had all explosive material removed and replaced with non-explosive material, (2) empty ammunition or components, and (3) ammunition or components that were manufactured with non-explosive material in place of all explosive material. These practice munitions vary in size from 25 to 500 lb. and are designed to simulate the characteristics of explosive munitions for training and testing activities. Some non-explosive practice munitions may also contain unburned propellant (e.g., rockets), and some may contain spotting charges or signal cartridges for locating the point of impact (e.g., smoke charges for daylight spotting or flash charges for night spotting) (U.S. Department of the Navy, 2010a). Non-explosive bombs—also called "practice" or "bomb dummy units"—are composed mainly of iron and steel casings filled with sand, concrete, or vermiculite. These materials are similar to those used to construct artificial reefs. Large, non-explosive bombs are configured to have the same weight, size, center of gravity, and ballistics as explosive bombs (U.S. Department of the Navy, 2006). Practice bombs do not contain the explosives materials.

Decommissioned vessels used as targets for sinking exercises are selected from a list of U.S. Navy-approved vessels that have been cleaned or remediated in accordance with USEPA guidelines. By rule, vessel-sinking exercises must be conducted at least 50 NM offshore and in water at least 6,000 ft.

deep (40 CFR part 229.2). The USEPA requires the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.).

In general, three things happen to materials that come to rest on the ocean floor: (1) they lodge in sediments where there is little or no oxygen below 4 in., (2) they remain on the ocean floor and begin to react with seawater, or (3) they remain on the ocean floor and become encrusted by marine organisms. As a result, rates of deterioration depend on the metal or metal alloy and the conditions in the immediate marine and benthic environment. If buried deep in ocean sediments, materials tend to decompose at much lower rates than when exposed to seawater (Ankley, 1996). With the exception of torpedo guidance wires and sonobuoy parts, sediment burial appears to be the fate of most munitions used in marine warfare (Environmental Sciences Group, 2005).

When metals are exposed to seawater, they begin to slowly corrode, a process that creates a layer of corroded material between the seawater and uncorroded metal. This layer of corrosion removes the metal from direct exposure to the corrosiveness of seawater, a process that further slows movement of the metals into the adjacent sediments and water column. This is particularly true of aluminum. Elevated levels of metals in sediments would be restricted to a small zone around the metal, and any release to the overlying water column would be diluted. In a similar fashion, as materials become covered by marine life, both the direct exposure of the material to seawater and the rate of corrosion decrease. Dispersal of these materials in the water column is controlled by physical mixing and diffusion, both of which tend to vary with time and location. The analysis of metals in marine systems begins with a review of studies involving metals used in military training and testing activities that may be introduced into the marine environment.

In one study, the water was sampled for lead, manganese, nickel, vanadium, and zinc at a shallow bombing range in Pamlico Sound (estuarine waters of North Carolina) immediately following a training event with non-explosive practice bombs. All water quality parameters tested, except nickel, were within the state limits. The nickel concentration was significantly higher than the state criterion, although the concentration did not differ significantly from the control site located outside the bombing range. The results suggest that bombing activities were not responsible for the elevated nickel concentrations (U.S. Department of the Navy, 2010a, 2012).

The results of a separate study conducted by the U.S. Marine Corps near the bombing sites in Pamlico Sound sampled sediments and water quality for 26 different constituents, including lead and magnesium, related to munitions use. With the exception of perchlorate, which was found at extremely low concentrations in only 4 of 95 sediment samples, no constituents were found above minimum detection limits (U.S. Department of the Navy, 2010a). The concentrations of all other chemical constituencies were believed to be consistent with background levels in nearshore sediments and sea water. Perchlorate concentrations in sediments near the bombing targets were more likely to be from naturally occurring sources rather than associated with bombing range activities given that perchlorate is extremely soluble in water. The results of the sampling indicate that munitions constituents are not accumulating at concentrations that pose a risk to ecological receptors or humans and are not migrating from the bombing sites to off-range areas.

A study by Pait et al. (2010) of previous Navy training areas at Vieques, Puerto Rico found generally low concentrations of metals in marine sediments. Areas in which live ammunition and loaded weapons were used (“live-fire areas”) were included in the analysis. These results are relevant because the concentrations of expended munitions at Vieques are significantly greater than would be found anywhere in the AFTT Study Area. Table 3.2-9 compares the sediment concentrations of several metals from those naval training areas with sediment screening levels established by the National Oceanic and Atmospheric Administration (Buchman, 2008).

As shown in Table 3.2-9, average sediment concentrations of the metals evaluated, except for copper, were below both the threshold and probable effects levels (metrics similar to the effects range levels). The average copper concentration was above the threshold effect level, but below the probable effect level. For other elements: (1) the mean sediment concentration of arsenic at Vieques was 4.37 micrograms per gram (μg/g), and the highest concentration was 15.4 μg/g. Both values were below the sediment quality guidelines examined, and (2) the mean sediment concentration of manganese in sediment was 301 μg/g, and the highest concentration was 967 μg/g (Pait et al., 2010). The National Oceanic and Atmospheric Administration did not report threshold or probable effects levels for manganese.

Table 3.2-9: Concentrations of and Screening Levels for Selected Metals in Marine Sediments, Vieques, Puerto Rico

Metal	*Sediment Concentration (μg/g)*			*Sediment Guidelines – National Oceanic and Atmospheric Administration (μg/g)*	
	Minimum	*Maximum*	*Average*	*Threshold Effects Level**	*Probable Effects Level**
Cadmium	0	1.92	0.15	0.68	4.21
Chromium	0	178	22.5	52.3	160
Copper	0	103	25.9	18.7	390
Lead	0	17.6	5.42	30.24	112
Mercury	N/R	0.112	0.019	130	700
Nickel	N/R	38.3	7.80	15.9	42.8
Zinc	N/R	130	34.4	124	271

*Threshold Effects Level and Probable Effects Level are metrics similar to the effects range metrics (i.e., Effects Range-Low and Effects Range-Median) used to assess potential effects of contaminants on sediments. The Threshold Effects Levels is the average of the 50th percentile and the 15th percentile of a dataset and the Probable Effects Level is the average of the 50th percentile and the 85th percentile of a dataset.
Notes: μg/g = micrograms per gram, N/R = not reported

The impacts of lead and lithium were studied at the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada (Environmental Sciences Group, 2005). These materials are common to expendable mobile anti-submarine warfare training targets, acoustic device countermeasures, sonobuoys, and torpedoes. The study noted that lead is a naturally occurring metal in the environment, and that typical concentrations of lead in seawater in the test range were between 0.01 and 0.06 ppm, while concentration of lead in sediments was between 4 and 16 ppm. Cores of marine sediments in the test range show a steady increase in lead concentration from the bottom of the core to a depth of approximately 20 cm. This depth corresponds to the late 1970s and early 1980s, and the lead contamination was attributed to atmospheric deposition of lead from gasoline additives. The sediment cores showed a general reduction in lead concentration to the present time, coincident with the phasing out of lead in gasoline by the mid-1980s. The study also noted that other training ranges have shown minimal impacts of lead ballasts because they are usually buried deep in marine sediments where they are not biologically available. The study concluded that the lead ballasts would not adversely impact marine organisms because of the low probability of mobilization of lead.

A study by the Navy examined the impacts of materials from activated seawater batteries in sonobuoys that freely dissolve in the water column (e.g., lead, silver, and copper ions), as well as nickel-plated steel housing, lead solder, copper wire, and lead shot used for sonobuoy ballast (U.S. Department of the Navy, 1993). The study concluded that constituents released by saltwater batteries as well as the decomposition of other sonobuoy components did not exceed state or federal standards, and that the reaction products are short-lived in seawater.

A series of research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016; University of Hawaii, 2010) and an intensively used live fire range in the Mariana Islands (Smith & Marx, 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life.

On a localized scale, research at World War II munitions ocean disposal sites in Hawaii investigated nearby sediments, seawater, or marine life to determine if metals could be detected. For metals, although there were localized elevated levels of arsenic and lead in several biota samples and in the sediment adjacent to the munitions, the origin of those metals could not be definitively linked to the munitions since comparison of sediment between the clean reference site and the disposal site showed relatively little difference. This was especially the case for a comparison with samples for ocean disposed dredge spoils sites (locations where material taken from the dredging of harbors on Oahu was disposed). At individual sampling sites adjacent to munitions, the concentrations of metals were not significantly higher as compared to the background at control sites and not significant in comparison to typical deep-sea marine sediments (Briggs et al., 2016). Observations and data collected also did not indicate any adverse impact to the localized ecology due to the presence of munitions degrading for over 75 years when compared to control sites. When specifically looking at marine organisms around the munitions (Kelley et al., 2016; Koide et al., 2016), the analysis indicated that in soft bottom habitats the expended items were providing hard substrate similar to other disposed objects or “artificial reefs” that attracted “hard substrate species” that would not have otherwise colonized the area and that there was no bioaccumulation of munitions-related chemicals for the species sampled (Koide et al., 2016).

On a broader scale, 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 & Marx, 2016). Munitions use has included explosive rounds from gunfire, high explosive 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, 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 & Marx, 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 those performed 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 Dahlgren have included rounds from small-caliber guns up to the Navy’s largest (16-in. guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (U.S. Department of the Navy, 2013b). Results from the assessment indicate that munitions expended at Dahlgren have not contributed significant concentrations of metals to the Potomac River and that the concentrations of metals in local sediments are orders of magnitude lower than in other areas of the Potomac River where metals are introduced from natural and other manmade sources (U.S. Department of the Navy, 2013a).

3.2.3.3.1 Impacts from Metals under Alternative 1

3.2.3.3.1.1 Impacts from Metals under Alternative 1 for Training Activities

Many activities included in the Proposed Action would involve the expenditure of munitions and other materials with metal components. Refer to Chapter 2 (Description of Proposed Action and Alternatives) for information on training activities and their frequency of annual occurrence under Alternative 1 and Appendix A (Navy Activity Descriptions) for a detailed description of munitions and other materials that would be used during training activities.

The distribution of non-explosive munitions and other expended materials composed of or containing metals that are used in training activities is not uniform throughout the Study Area. Non-explosive munitions are the largest portion of expended objects composed of metal or containing metal components (with the exception of target vessels). Approximately 50 percent of the non-explosive munitions and other expended metals used annually during training activities would be used in the Virginia Capes Range Complex, 24 percent in the Jacksonville Range Complex, and 15 percent would be used in the Navy Cherry Point Range Complex. The remaining 11 percent would be distributed in other locations of the Study Area. Over 8 million munitions and other items containing metals would be used in the Study Area annually; 75 percent of those munitions and items are small-caliber projectiles and over 20 percent are medium-caliber projectiles. Small-caliber projectiles are less than 0.5 in. in diameter and a few inches in length, and weigh up to 0.17 lb. A 30 mm medium-caliber projectile is larger, weighing just under 1 lb., and it is approximately 30 mm (or about 1 in.) in diameter and 7 in. long.

While the Navy is proposing to conduct one Sinking Exercise per year, historically, the Navy has not conducted this activity on an annual basis. The last Sinking Exercise conducted in the Atlantic was in 2009; one was also conducted in 2008. A Navy vessel used as a target would weigh between 5,000 and 10,000 tons (aircraft carriers would not be used as a target in Sinking Exercises). The vessel used during the Sinking Exercise would comprise a substantial amount of the metal used in the Study Area by weight, and would also represent the greatest concentration of expended metal objects (including munitions) in any location in the Study Area once the vessel sinks to the seafloor. As noted in previous sections, decommissioned vessels used as targets for sinking exercises have been cleaned or remediated in accordance with USEPA guidelines. Sinking exercises must be conducted at least 50 NM offshore and in water at least 6,000 ft. deep (40 CFR part 229.2). The USEPA considers the contaminant levels associated with the sinking of a target vessel to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.).

Metals from munitions, vessels and other targets, and other expended materials would sink to the seafloor where they would most likely be buried or partially buried in sediments, depending on the type of seafloor substrate. In the AFTT Study Area, the offshore substrate is predominantly composed of soft sediments (see Section 3.5, Habitats), which would increase the likelihood of complete or partial burial of expended materials, including munitions. Metals exposed to the seawater would slowly corrode over years or decades, releasing small amounts of water soluble metal compounds into the water column and corrosion products into adjacent sediments. The low, near freezing water temperatures and low oxygen levels in sediments only a few inches below the water column-seafloor interface that characterize deep water (greater than 250 m), benthic habitats would inhibit corrosion of metals and any dispersion of metals and corrosion products beyond isolated areas adjacent to the munition.

As described in Section 3.2.3.3 (Metals), sediment samples collected from World War II era munitions disposal sites and heavily used Navy ranges show that metals are not impacting sediment quality despite longtime use and high concentrations of military munitions composed primarily of metal components. The concentration of munitions and other expended materials containing metals in any one location in the AFTT Study Area would be a small fraction of that from a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. Chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable and would be similar to nearby areas without munitions or other expended materials containing metals. This conclusion is based on the following: (1) most of the metals are benign, and those of potential concern make up a small percentage of expended munitions and other metal objects; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediment; (3) elevated concentrations of metals in sediments would be limited to the immediate area around the expended material; and (4) the areas over which munitions and other metal components would be distributed are large.

Based on findings from these and other intensively used locations, the sediment and water quality effects from metals used in munitions, expended materials, target vessels, or other devices resulting from any of the proposed activities would be negligible by comparison.

3.2.3.3.1.2 Impacts from Metals under Alternative 1 for Testing Activities

The distribution of non-explosive munitions and other expended materials composed of or containing metals that are used in testing activities is not uniform throughout the Study Area. Munitions are the largest portion of expended objects composed of metal or containing metal components. Approximately 36 percent of the non-explosive munitions and other expended metals used annually during testing activities would be used in the Virginia Capes Range Complex, and 29 percent would be used in the Jacksonville Range Complex. The remaining 35 percent would be more widely distributed in other locations of the Study Area. Over 12 million munitions and other items containing metals would be used in the Study Area annually; over 45 percent of those munitions and items are non-explosive medium-caliber projectiles, 17 percent are non-explosive large-caliber projectiles, and 10 percent are small-caliber projectiles.

As described in Section 3.2.3.3 (Metals), sediment samples collected from World War II era munitions disposal sites and heavily used Navy ranges show that metals are not impacting sediment quality despite longtime use and high concentrations of military munitions composed primarily of metal components. The concentration of munitions and other expended materials containing metals in any one location in the Study Area would be a small fraction of that found in a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. Chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable and would be similar to nearby areas without munitions or other expended materials containing metals. This conclusion is based on the following: (1) most of the metals are benign, and those of potential concern make up a small percentage of expended munitions and other metal objects; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediment; (3) elevated concentrations of metals in sediments would be limited to the immediate area around the expended material; and (4) the areas over which munitions and other metal components would be distributed are large (thousands of square nautical miles).

Based on findings from these and other intensively used locations, the sediment and water quality effects from metals used in munitions, expended materials, or other devices resulting from any of the proposed activities would be negligible by comparison.

3.2.3.3.2 Impacts from Metals under Alternative 2

3.2.3.3.2.1 Impacts from Metals under Alternative 2 for Training Activities

Under Alternative 2, the number of munitions and other expended materials containing metals used during training activities would be the same as under Alternative 1. Therefore, metals contained in munitions and other military expended materials would have the same environmental impacts as described under Alternative 1.

3.2.3.3.2.2 Impacts from Metals under Alternative 2 for Testing Activities

Under Alternative 2, the number of munitions and other expended materials containing metals used during testing activities would increase compared to the number under Alternative 1. As shown in Chapter 2 (Description of Proposed Action and Alternatives) Tables 2.6-2 through 2.6-4, several Navy testing activities would be conducted more often under Alternative 2, resulting in an increase of 10 explosive mines and 40 neutralizers (10 explosive and 30 non-explosive) used annually. Under Alternative 1, no explosive mines would be used by Naval Air Systems Command. In addition, some activities would be conducted more frequently over a five-year period, resulting in the use of more munitions and other expended materials (see Tables 2.6-2 through 2.6-4). Over a five-year period, there would be an overall 8 percent increase in munitions and other expended materials containing metals used under Alternative 2. These include 300 additional torpedo accessories, which contain lead ballast; over 600 neutralizers, over 70,000 medium-caliber projectiles (30 percent explosive and 70 percent non-explosive); 170 missiles (70 percent explosive and 30 percent non-explosive); over 600 rockets (60 percent explosive and 40 percent non-explosive); and 60 surface targets.

The increase in the use of munitions and other objects containing metals would increase the amount of metals introduced into the seafloor environment over the amount in Alternative 1. However, the increase is not a substantial increase over the number of munitions used under Alternative 1 and would not alter the conclusions presented for Alternative 1. Specifically, the concentration of munitions and other expended materials containing metals in any one location in the AFTT Study Area would be a small fraction of the concentrations found on a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. The increase in the chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable. The areas over which the additional 9 percent of munitions and other metal components would be distributed are large (thousands of square nautical miles); therefore, any increase would have a negligible effect on metal concentrations in seafloor sediments.

Based on findings from intensively used locations, the sediment and water quality effects from metals used in munitions, expended materials, or other devices resulting from any of the proposed activities would be negligible by comparison. Therefore, metals in munitions and other military expended materials are expected to have similar potential environmental impacts as under Alternative 1.

3.2.3.3.3 Impacts from Metals under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no adverse impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of non-explosive munitions and other expended materials containing metals would decrease the amounts of metal contaminants in marine waters and sediments. The effect, however, would likely not be measurable due to the slow, sometimes decades-long corrosion rates of metals on the seafloor. Metals released into sediments from corroding munitions and other metallic materials would only be expected at marginally higher concentrations in sediments within a few feet of the munition relative to a nearby location without munitions. Furthermore, most metals used in non-explosive munitions and other expended materials occur naturally in the marine environment and would not be elevated to toxic levels by slowly corroding munitions or other metallic materials.

3.2.3.4 Other Materials

Under the Proposed Action, other materials include marine markers and flares, chaff, towed and stationary targets, and miscellaneous components of other expended objects. These materials and components are either made mainly of non-reactive or slowly reactive materials (e.g., glass, carbon fibers, and plastics) or break down or decompose into benign byproducts (e.g., rubber, steel, iron, and concrete). Most of these objects would settle to the seafloor where they would (1) be exposed to seawater, (2) become lodged in or covered by seafloor sediments, (3) become encrusted by oxidation products such as rust, (4) dissolve slowly, or (5) be covered by marine organisms such as coral. Plastics may float or descend to the bottom, depending upon their buoyancy. Marine markers and flares are largely consumed during use.

Towed and stationary targets include floating steel drums, towed aerial targets, the trimaran, and inflatable, floating targets. The trimaran is a three-hulled boat with a 4 ft. square sail that is towed as a moving target. Large, inflatable, plastic targets can be towed or left stationary. Towed aerial targets are either (1) rectangular pieces of nylon fabric 7.5 ft. by 40 ft. that reflect radar or lasers or (2) aluminum cylinders with a fiberglass nose cone, aluminum corner reflectors (fins), and a short plastic tail section. This second target is about 10 ft. long and weighs about 75 lb. These four targets are recovered after use, and will not be considered further.

Marine markers are pyrotechnic devices that are dropped on the water's surface during training exercises to mark a position, to support search and rescue activities, or as a bomb target. The MK 58 marker is a tin tube that weighs about 12 lb. Markers release smoke at the water surface for 40 to 60 minutes. After the pyrotechnics are consumed, the marine marker fills with seawater and sinks. Iron and aluminum constitute 35 percent of the marker by weight. To produce the lengthy smoke effect, approximately 40 percent of the marker by weight is made up of pyrotechnic materials. The propellant, explosive, and pyrotechnic constituents of the MK 58 include red phosphorus (2.19 lb.) and manganese (IV) dioxide (1.40 lb.). Other constituents include magnesium powder (0.29 lb.), zinc oxide (0.12 lb.), nitrocellulose (0.000017 lb.), nitroglycerin (0.000014 lb.), and potassium nitrate (0.2 lb.). The failure rate of marine markers is approximately 5 percent (U.S. Department of the Navy, 2010a, 2010b).

Flares are used to signal, to illuminate surface areas at night in search and attack operations, and to assist with search and rescue activities. They range in weight from 12 to 30 lb. The major constituents of flares include magnesium granules and sodium nitrate. Containers are constructed of aluminum, and the entire assembly is usually consumed during flight. Flares may also contain a primer such as trinitrotoluene (TNT), propellant (ammonium perchlorate), and other explosives. These materials are present in small quantities (e.g., 1.0 x 10^{-4} ounces [oz.] of ammonium perchlorate and 1.0 x 10^{-7} oz. of explosives). Small amounts of metals are used to give flares and other pyrotechnic materials bright and distinctive colors. Combustion products from flares include magnesium oxide, sodium carbonate, carbon dioxide, and water. Illuminating flares and marine markers are usually entirely consumed during use; neither is intended to be recovered. Table 3.2-10 summarizes the components of markers and flares (U.S. Air Force, 1997).

Table 3.2-10: Summary of Components of Marine Markers and Flares

Flare or Marker	*Constituents*	*Composition (%)*
LUU-2 Paraflare	Magnesium granules, sodium nitrate, aluminum, iron, trinitrotoluene (TNT), royal demolition explosive, ammonium perchlorate, potassium nitrate, lead, chromium, magnesium, manganese, nickel	Magnesium (54), sodium nitrate (26), aluminum (14), iron (5)
MK45 Paraflare	Aluminum, sodium nitrate, magnesium powder, nitrocellulose, trinitrotoluene (TNT), copper, lead, zinc, chromium, manganese, potassium nitrate, pentaerythritol-tetranitrate, nickel, potassium perchlorate	Magnesium (45), sodium nitrate (30), aluminum (22)
MK58 Marine Marker	Aluminum, iron, chromium, copper, lead, lead dioxide, manganese dioxide, manganese, nitroglycerin, red phosphorus, potassium nitrate, silver, zinc, zinc oxide	Iron (60), aluminum (35)

Most of the pyrotechnic components of marine markers are consumed and byproducts are released into the air. Thereafter, the aluminum and steel canister sinks to the bottom. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms. The amount of flare residue is negligible. Phosphorus contained in the marker settles to the seafloor, where it reacts with the water to produce phosphoric acid until all phosphorus is consumed by the reaction. Phosphoric acid is a variable, but normal, component of seawater (Sverdrup et al., 1970). The aluminum and iron canisters are expected to be covered by sand and sediment over time, to become encrusted by chemical corrosion, or to be covered by marine plants and animals. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, adheres to particulates, and is transported to the bottom sediments (Monterey Bay Research Institute, 2010).

Red phosphorus, the primary pyrotechnic ingredient, constitutes 18 percent of the marine marker weight. Toxicological studies of red phosphorus revealed an aquatic toxicity in the range of 10–100 milligrams per liter (10–100 ppm) for fish, *Daphnia* (a small aquatic crustacean), and algae (European Flame Retardants Association, 2002). Red phosphorus slowly degrades by chemical reactions to phosphine and phosphorus acids. Phosphine is very reactive and usually undergoes rapid oxidation. The final products, phosphates, are harmless (Salocks & Kaley, 2003). A study by the U.S. Air Force (1997) found that, in salt water, the degradation products of flares that do not function properly include magnesium and barium.

Chaff is an electronic countermeasure designed to confuse enemy radar by deflecting radar waves and thereby obscuring aircraft, ships, and other equipment from radar tracking sources. Chaff consists of small, thin glass fibers coated in aluminum that are light enough to remain in the air anywhere from 10 minutes to 10 hours (Farrell & Siciliano, 2007). Chaff is typically packaged in cylinders that measure approximately 6 in. by 1.5 in. (15.2 cm by 3.8 cm), weigh about 5 oz. (140 grams [g]), and contain a few million fibers. Chaff may be deployed from an aircraft or may be launched from a surface vessel.

The chaff fibers are approximately the thickness of a human hair (generally 25.4 microns in diameter), and range in length from 0.8 to 5.1 cm. The major components of the chaff glass fibers and the aluminum coating are provided in Table 3.2-11 (Arfsten et al., 2002; Farrell & Siciliano, 2007; Spargo, 1999; U.S. Air Force, 1997; U.S. Department of the Navy, 1999).

Factors influencing chaff dispersion include the altitude and location where it is released, prevailing winds, and meteorological conditions (Spargo, 1999, 2007). Doppler radar has tracked chaff plumes containing approximately 900 g of chaff drifting 200 mi. from the point of release, with the plume covering a volume of greater than 400 cubic miles (Arfsten et al., 2002). Based on the dispersion characteristics of chaff, large areas of open water would be exposed to chaff, but the chaff concentrations would be low. For example, Spargo (1999) calculated that an area 8 km by 12 km (96 square kilometers) would be affected by deployment of a single cartridge containing 150 g of chaff. The resulting chaff concentration would be about 5.4 g per NM^2. This corresponds to less than 0.005 fiber per square meters, assuming that each canister contains 5 million fibers.

Chaff is generally resistant to chemical weathering and likely remains in the environment for long periods. However, all the components of chaff's aluminum coating are present in seawater in trace amounts, except magnesium, which is present at 0.1 percent (Nozaki, 1997). Aluminum and silicon are the most common minerals in the earth's crust as aluminum oxide and silicon dioxide, respectively. Aluminum is the most common metal in the Earth's crust and also occurs naturally in trace amounts in the aquatic environment. Ocean waters are constantly exposed to these minerals, so the addition of small amounts of chaff would not affect water quality or sediment composition (Spargo, 1999).

Table 3.2-11: Major Components of Chaff

Component	***Percent by Weight***
Glass Fiber	
Silicon dioxide	52–56
Alumina	12–16
Calcium oxide, magnesium oxide	16–25
Boron oxide	8–13
Sodium oxide, potassium oxide	1–4
Iron oxide	≤ 1
Aluminum Coating	
Aluminum	99.45 (minimum)
Silicon and Iron	0.55 (maximum)
Copper	0.05
Manganese	0.05
Zinc	0.05
Vanadium	0.05
Titanium	0.05
Others	0.05

The dissolved concentration of aluminum in seawater ranges from 1 to 10 µg/L (1 to 10 ppb). For comparison, the concentration in rivers is 50 µg/L (50 ppb). In the ocean, aluminum concentrations tend to be higher on the surface, lower at middle depths, and higher again at the bottom (Li et al., 2008). Aluminum is a very reactive element, and is seldom found as a free metal in nature except under highly acidic (low pH) or alkaline (high pH) conditions. It is found combined with other elements, most commonly with oxygen, silicon, and fluorine. These chemical compounds are commonly found in soil, minerals, rocks, and clays (Agency for Toxic Substances and Disease Registry, 2008; U.S. Department of the Air Force, 1994). Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and is scavenged by particulates and transported to bottom sediments (Monterey Bay Research Institute, 2010).

Because of their light weight, chaff fibers tend to float on the water surface for a short period. The fibers are quickly dispersed by waves and currents. They may be accidentally or intentionally ingested by marine life, but the fibers are non-toxic. Chemicals leached from the chaff would be diluted by the surrounding seawater, reducing the potential for chemical concentrations to reach levels that can affect sediment quality or benthic habitats.

Systems Consultants (1977) placed chaff samples in Chesapeake Bay water for 13 days. No increases in concentration of greater than 1 ppm of aluminum, cadmium, copper, iron, or zinc were detected. Accumulation and concentration of chaff constituents is not likely under natural conditions. A U.S. Air Force study of chaff analyzed nine elements under various pH conditions: silicon, aluminum, magnesium, boron, copper, manganese, zinc, vanadium, and titanium. Only four elements were detected above the 0.02 milligrams per liter detection limit (0.02 ppm): magnesium, aluminum, zinc, and boron (U.S. Air Force, 1994). Tests of marine organisms detected no impacts of chaff exposure at levels above those expected in the Study Area (Farrell & Siciliano, 2007).

3.2.3.4.1 Impacts from Other Materials under Alternative 1

3.2.3.4.1.1 Impacts from Other Materials under Alternative 1 for Training Activities

The distribution of other expended materials used in training activities would not be uniform throughout the Study Area. These other expended materials include marine markers and flares, chaff, expendable towed and stationary targets, non-explosive sonobuoys, fiber-optic cables, and miscellaneous components. Approximately 44 percent of these other expended materials would be used annually in the Jacksonville Range Complex, 30 percent in the Key West Range Complex, and 20 percent would be used in the Navy Cherry Point Range Complex. Over 270,000 other expended materials would be used in the Study Area annually; 46 percent of those materials are chaff, 34 percent are flares, and 16 percent are non-explosives sonobuoys (i.e., passive and acoustic), which contain metals and other materials including plastics. The composition of chaff is much like clay minerals common in ocean sediments (aluminosilicates), and studies indicate that impacts are not anticipated even at concentrations many times the level anticipated during proposed training activities. Most pyrotechnics in marine markers and flares are consumed during use and combustion byproducts are expended into the air. The failure rate of flares and marine markers is low (5 percent), and the remaining amounts are small and subject to additional chemical reactions and subsequent dilution in the ocean.

Under Alternative 1, approximately 94,000 flares would be used in the AFTT Study Area, and approximately 4,700 (5 percent) would enter the water with unconsumed pyrotechnic materials. As show in Table 3.2-10, the bulk of these materials are metals and other chemical compounds that occur naturally in the marine environment and would be dispersed at low concentrations in the water column or would sink to the seafloor. The analysis and conclusions presented in Section 3.2.3.3 (Metals) would apply to metals in pyrotechnics as well, and the analysis concludes that sediment and water quality effects from metals would be negligible. The small amounts of explosives used in flares, specifically trinitrotoluene (TNT) and royal demolition explosive, released into the sediments would not impact marine sediments for the same reasons presented in Section 3.2.3.1 (Explosives and Explosives Byproducts). Based on the results of studies conducted at multiple marine and freshwater ranges where explosives have been used intensively over decades, no impacts on sediments and water quality from explosives in unconsumed flares would be expected.

Plastics and other floating expended materials (e.g., rubber components) would either degrade over time in the water column or on the seafloor or wash ashore. Materials that sink to the seafloor would be widely distributed over the large areas used for training. As described in Section 3.2.2.1.2 (Marine Debris, Military Materials, and Marine Sediments), the worldwide use and disposal of plastics is rapidly increasing the amount of plastic debris accumulating in large areas of the world's oceans. Small pieces of plastic associated with the use of chaff, flares, and targets would likely persist in the marine environment as floating debris in the water column or on the seafloor. Plastic floating near the surface and exposed to the sun and mechanical wear and tear would break down over time. Plastic that sinks in the water column below the photic zone or to the seafloor would degrade more slowly or not at all. Because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area, only negligible impacts on sediments or water quality are expected. The potential effects of plastic from military expended materials on living marine resources and habitats are analyzed in other sections of the EIS/OEIS.

Devices temporarily deployed on the seafloor and then recovered following completion of the activity would likely increase turbidity in the vicinity of the device. Most seafloor devices are stationary; however, some devices (e.g., crawlers) are mobile and move very slowly along the bottom. While a minimal increase in turbidity would be expected during installation, recovery, and, if applicable, movement of seafloor devices, particularly where the seafloor is composed of soft sediments, the increase is expected to be negligible and have no lasting impact on sediments or water quality.

3.2.3.4.1.2 Impacts from Other Materials under Alternative 1 for Testing Activities

The distribution of other expended materials used in testing activities would not be uniform throughout the Study Area. These other expended materials include marine markers and flares, chaff, expendable towed and stationary targets, non-explosive sonobuoys, fiber-optic cables, and miscellaneous components. Approximately 35 percent of these other expended materials would be used annually in the Virginia Capes Range Complex, 29 percent in the Jacksonville Range Complex, 9 percent would be used in the Gulf of Mexico Range Complex, and 8 percent each would be used in the Key West Range Complex and the Northeast Range Complexes. The remaining 11 percent would be distributed in other locations of the Study Area. Over 264,000 other expended materials would be used in the Study Area annually; 65 percent of those materials are sabots. A sabot is a device used to keep a projectile centered in the barrel during firing. Sabots are constructed of metal with plastic parts. Of the remaining other expended materials, 13 percent are non-explosive sonobuoys, 9 percent are chaff, and 8 percent are flares.

Most pyrotechnics in marine markers and flares are consumed during use combustion byproducts are expended into the air. The failure rate of flares and marine makers is low (5 percent), and the remaining amounts are small and subject to additional chemical reactions and subsequent dilution in the ocean. The analysis and conclusions presented in Section 3.2.3.3 (Metals) would apply to metals in pyrotechnics as well, and the analysis concludes that sediment and water quality effects from metals would be negligible. The small amounts of explosives used in flares, specifically trinitrotoluene (TNT) and royal demolition explosive, released into the sediments would not impact marine sediments for the same reasons presented in Section 3.2.3.1 (Explosives and Explosives Byproducts). Based on the results of studies conducted at multiple marine and freshwater ranges where explosives have been used intensively over decades, no impacts on sediments and water quality from explosives in unconsumed flares would be expected.

Plastics and other floating expended materials (e.g., rubber components) would either degrade over time in the water column or on the seafloor or wash ashore. Materials that sink to the seafloor would be widely distributed over the large areas used for testing. As described in Section 3.2.2.1.2 (Marine Debris, Military Materials, and Marine Sediments), the worldwide use and disposal of plastics is rapidly increasing the amount of plastic debris accumulating in large areas of the world's oceans. Small pieces of plastic associated with the use of chaff, flares, and targets would likely persist in the marine environment as floating debris in the water column or on the seafloor. Plastic floating near the surface and exposed to the sun and mechanical wear and tear would break down over time. Plastic that sinks in the water column below the photic zone or to the seafloor would degrade more slowly or not at all. Because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area, only negligible impacts on sediments or water quality are expected. The potential effects of plastic from military expended materials on living marine resources and habitats are analyzed in other sections of the Final EIS/OEIS. Some testing activities would involve the use of a biodegradable polymer as part of a vessel entanglement system. Based on the constituents of the biodegradable polymer, the Navy anticipated that the material will break down into small pieces within a few days to weeks. The polymer will break down further and dissolve into the water column within weeks to a few months. The final breakdown products are all environmentally benign and will be dispersed quickly to undetectable concentrations within the water column.

Devices temporarily deployed on the seafloor and then recovered following completion of the activity would likely increase turbidity in the vicinity of the device. Most seafloor devices are stationary; however, some devices (e.g., crawlers) are mobile and move very slowly along the bottom. While a minimal increase in turbidity would be expected during installation, recovery, and, if applicable, movement of seafloor devices, particularly where the seafloor is composed of soft sediments, the increase is expected to be negligible and have no lasting impact on sediments or water quality.

3.2.3.4.2 Impacts from Other Materials under Alternative 2

3.2.3.4.2.1 Impacts from Other Materials under Alternative 2 for Training Activities

Under Alternative 2, the number of other expended materials would increase by just 0.6 percent. The additional expended materials are non-explosive buoys and their small decelerators/parachutes and bathythermographs. The small increase in plastics, metals, and explosives in the additional expended materials would not change the conclusions presented under Alternative 1. Therefore, impacts from other materials would be expected to be the same as those analyzed under Alternative 1.

3.2.3.4.2.2 Impacts from Other Materials under Alternative 2 for Testing Activities

Under Alternative 2, the number of other expended materials would increase by 0.3 percent. The additional expended materials are non-explosive sonobuoys and their small decelerators/parachutes. The small increase in plastics and metals in the additional expended materials would not change the conclusions presented under Alternative 1. Therefore, impacts from other materials would be expected to be the same as those analyzed under Alternative 1.

3.2.3.4.3 Impacts from Other Materials under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no adverse impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of military expended materials would decrease the amounts of these materials in marine waters and sediments. The effect, however, would likely not be measurable due to the slow, sometimes decades-long degradation of these materials, including plastics, in the water column and on the seafloor. Other expended materials in sediments would have only negligible impacts, because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area.

3.2.4 Summary of Potential Impacts on Sediments and Water Quality

The stressors that may impact sediments and water quality include explosives and explosives byproducts, metals, chemicals other than explosives, and other materials. As described in Section 3.0.3.5 (Resource-Specific Impacts Analysis for Multiple Stressors), this section evaluates the potential for combined impacts of all the stressors on sediments and water quality. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in the sections above. Stressors associated with Navy training and testing activities do not typically occur in isolation but rather occur in some combination. For example, some anti-submarine warfare activities use explosive sonobuoys, which may introduce residual explosives, explosives byproducts, metals, and plastic materials into the environment during a single activity. An analysis of the combined impacts of all stressors on sediments and water quality considers the potential consequences of aggregate exposure to all stressors and the repetitive or additive consequences of exposure over multiple years.

3.2.4.1 Combined Impact of all Stressors under Alternative 1

Most Navy training and testing activities impact small, widely dispersed areas of the Study Area, limiting the spatial extent of sediments and the water column that would be exposed to contaminants to isolated areas within the Study Area. However, some Navy activities recur in the same location (e.g., gunnery and mine warfare activities), which concentrates munitions and other materials and their associated stressors in those areas. Despite recent, comprehensive data collection and analysis specific to military munitions impacts on sediments and water quality (Briggs et al., 2016; Edwards & Bełdowski, 2016; Edwards et al., 2016; Tomlinson & De Carlo, 2016), analysis of the potential effects from the Proposed Action is mainly qualitative. Where combinations of explosives, explosives byproducts, metals, and other chemicals and materials are co-located, the potential for combined impacts is present (Thompson et al., 2009).

When considered together, the impact of the four stressors would be additive. Under Alternative 1, chemical, physical, or biological changes in sediments and water quality would be minimal and only detectable in the immediate vicinity of munitions. Even in areas where multiple munitions and expended materials are located in close proximity (e.g., munitions disposal sites) chemical degradation products from each source or item are largely isolated from each other. The low failure rate of explosive munitions proposed for use reduces the likelihood of exposure to explosives materials that remain in intact munitions. Measurable concentrations of contaminants and other chemicals in the marine environment from munitions disposal sites have been shown to be below screening levels or similar to nearby reference areas where munitions are not present. Many components of non-explosive munitions and other expended materials are inert or corrode slowly over years. Metals that could impact benthic habitat at higher concentrations comprise only a small portion of the alloys used in expended materials, and corrosion of metals in munitions casings and other expended materials is a slow process that allows for dilution. The chemicals products from hydrolysis are predominantly naturally occurring chemicals. Elevated concentrations of metals and other chemical constituents in sediments would be limited to small zones adjacent to the munitions or other expended materials and would still most likely remain below screening levels even after years residing on the seafloor. It is also possible that Navy stressors will combine with non-Navy stressors, particularly in nearshore areas and bays, such as the mouth of Chesapeake Bay, to exacerbate already impacted sediments and water quality. This is qualitatively discussed in Chapter 4 (Cumulative Impacts).

3.2.4.2 Combined Impact of all Stressors under Alternative 2

Under Alternative 2, when considered separately, the impacts of the four stressors on sediments and water quality would be the same as discussed under Alternative 1, because the types and amounts of explosives, chemicals other than explosives, metals, and military expended materials are approximately equivalent under the two alternatives.

The amounts of explosives are greater under Alternative 2, because of the nominal increase in munitions used in some testing activities under Alternative 2. While the potential impact to sediments would be greater than under Alternative 1, metals in the additional munitions would be subject to the same slow degradation rates expected to occur in the deepwater environment limiting any increase in metal concentrations to sediments that are immediately adjacent a munition (see Section 3.2.3.3, Metals, for additional discussion). As non-explosive or unexploded munitions degrade over time on the seafloor, they may become encrusted with oxidation products (e.g., rust) or by marine organisms attracted to hard substrates, which would further slow degradation rates. As discussed in Section 3.2.3.1 (Explosives and Explosives Byproducts), degrading munitions at World War II era munitions disposal sites do not pose a risk to human health or to the fauna living in direct contact with the degrading munitions (Edwards et al., 2016). During a comprehensive survey of a disposal site off of Hawaii, explosive materials were detected in sediments at only two locations and the concentrations were low. Data supporting these conclusions were collected from several World War II era munitions disposal sites and ranges characterized by relatively high concentrations of munitions. Munitions used in the proposed training and testing activities would be widely dispersed by comparison, resulting in lower concentrations of munitions that failed to detonate and lower concentrations of residual explosives and explosives byproducts than reported in Edwards et al. (2016).

Based on this analysis, impacts on sediments and water quality may be greater than under Alternative 1, but would still be minimal. Therefore, combined impacts from all stressors would also be similar to impacts described under Alternative 1.

3.2.4.3 Combined Impact of all Stressors under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no adverse impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of explosives and explosives byproducts, metals, chemicals other than explosives, and other materials would decrease the amounts these materials in marine waters and sediments. The effect, however, would likely not be measurable due to the slow, sometimes decades-long corrosion of metals on the seafloor. Metals, explosives, and explosives byproducts released into sediments from corroding munitions and other metallic materials would only be expected at marginally higher concentrations in sediments within a few feet of the munition relative to a nearby location without munitions. Furthermore, most metals used in non-explosive munitions and other expended materials occur naturally in the marine environment and would not be elevated to toxic levels by slowly corroding munitions or other metallic materials. The effect of chemicals other than explosives would likely not be measurable due to the highly efficient use of propellants and fuels by motors used in rockets and missiles, resulting in often undetectable trace amounts of propellants expended into the environment. Perchlorates, which make up a large percentage of rocket and missile propellants, are also water soluble and would dissolve and be dispersed in surface waters and would not accumulate in marine sediments. Other expended materials in sediments would have only negligible impacts, because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area.

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

TABLE OF CONTENTS

List of Figures

List of Tables

3.3 Vegetation

VEGETATION SYNOPSIS

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

- Acoustics: There is no evidence that underwater acoustic stressors impact marine vegetation. Acoustic stressors, therefore, are not analyzed for vegetation.
- Energy: Energy stressors are not applicable to vegetation because vegetation have a limited sensitivity to energy stressors and therefore will not be analyzed further in this section.
- Explosives: Explosives could affect vegetation by destroying individual plants or damaging parts of plants; however, there would be no persistent or large-scale effects on the growth, survival, distribution or structure of vegetation due to relatively fast growth, resilience, and abundance of the most affected species (e.g., phytoplankton, seaweed).
- Physical Disturbance and Strike: Physical disturbance and strike could affect vegetation by destroying individual plants or damaging parts of plants; however, there would be no persistent or large-scale effects on the growth, survival, distribution or structure of vegetation due to relatively fast growth, resilience, and abundance of the most affected species (e.g., phytoplankton, seaweed).
- Entanglement: Entanglement stressors are not applicable to vegetation due to the sedentary nature of vegetation and is not analyzed further in this section.
- Ingestion: Ingestion stressors are not applicable because all vegetation analyzed uses photosynthesis vice ingestion to obtain necessary nutrients. Therefore, the ingestion stressor is not analyzed for vegetation.
- Secondary: Project effects on sediment, water, or air quality would be minor, temporary, and localized and could have short-term, small-scale secondary effects on vegetation; however, there would be no persistent or large-scale effects on the growth, survival, distribution, or structure of vegetation due to relatively fast growth, resilience, and abundance of the most affected species (e.g., phytoplankton, seaweed).

3.3.1 Introduction

This section provides analysis of potential impacts on vegetation found in the Atlantic Fleet Training and Testing (AFTT) Study Area (Study Area) and an introduction to the species that occur in the Study Area.

Vegetation includes diverse taxonomic/ecological groups of marine algae throughout the Study Area, as well as flowering plants in the coastal and inshore waters. The types of vegetation present in the Study Area are described in this section and the affected environmental baseline is discussed in Section 3.3.2 (Affected Environment). The analysis of environmental consequences is presented in Section 3.3.3 (Environmental Consequences), and the potential impacts of Alternative 1 and Alternative 2 are summarized in Section 3.3.4 (Summary of Potential Impacts on Vegetation). Additional information on the biology, life history, and conservation of marine vegetation can be found on the websites of the following agencies and groups:

- National Marine Fisheries Service (NMFS)
- Conservation International
- Algaebase
- National Museum of Natural History

3.3.2 Affected Environment

Three subsections are included in this section. General background information is given in Section 3.3.2.1 (General Background), which provides brief summaries of habitat use and threats that affect or have the potential to affect natural communities of vegetation within the Study Area. Protected species listed under the Endangered Species Act (ESA) are described in Section 3.3.2.2 (Endangered Species Act-Listed Species). General types of vegetation that are not listed under the ESA are briefly reviewed in Section 3.3.2.3 (Species Not Listed under the Endangered Species Act).

3.3.2.1 General Background

3.3.2.1.1 Habitat Use

Factors that influence the distribution and abundance of vegetation in the coastal and open ocean areas of the Study Area are the availability of light, nutrients, salinity, substrate type (important for rooted or attached vegetation), storms and currents, tidal schedule, temperature, and grazing by herbivores (Green & Short, 2003; Short et al., 2007).

Marine ecosystems depend almost entirely on the energy produced by marine vegetation through photosynthesis (Castro & Huber, 2000), which is the transformation of the sun's energy into chemical energy. In the lighted surface waters of the open ocean and coastal waters, marine algae and flowering plants have the potential to provide oxygen and habitat for many organisms in addition to forming the base of the marine food web (Dawes, 1998).

The affected environment comprises two major ecosystem types - the open ocean and coastal waters (including the inshore waters of the Study Area), and two major habitat types: the water column and bottom (benthic) habitat. Vegetation grows only in the sunlit portions of the open ocean and coastal waters, referred to as the "photic" or "euphotic" zone, which extends to a maximum depth of roughly 200 meters (m) (National Ocean Service, 2015). Because depth in most of the open ocean exceeds the euphotic zone, benthic habitat for vegetation is limited primarily to the large marine ecosystem landward of the open ocean. The basic taxonomic groupings of vegetation include microalgae (e.g., phytoplankton), macroalgae (e.g., seaweed), submerged rooted vegetation (e.g., seagrass), and emergent wetlands (e.g., cordgrass).

The euphotic zones of the water column in the Study Area are inhabited by phytoplankton, single-celled (sometimes filamentous or chain forming), free-floating algae primarily of four groups including blue-green algae, dinoflagellates, coccolithophores, and diatoms. The importance of each group is summarized below (Levinton, 2013b, 2013c):

- Diatoms dominate the phytoplankton at high latitudes. They are single-celled organisms with shells made of silica, which sometimes form chains of cells.

- Blue-green algae are found in and may dominate nearshore waters of restricted circulation and/or brackish (low salinity) waters as well as the open ocean. Blue-green algae convert atmospheric nitrogen to ammonia which can then be taken up by plants and animals.
- Dinoflagellates are covered with cellulose plates that dominate the phytoplankton at low latitudes and in summer and autumn at higher latitudes. Rapid population increases in dinoflagellates can result in "red tides" and "harmful algal blooms." Toxins produced by some dinoflagellates accumulate in the animals that consume them and can cause poisoning among the higher level human and marine mammal consumers.
- Coccolithophores are nearly spherical and secrete a skeleton of calcium carbonate plates. They can be dominant in the phytoplankton of tropical as well as sub-polar seas. They account for approximately one-third of calcium carbonate production in the entire ocean.

Other types of algae that can also be abundant in the phytoplankton, although usually less so than the four groups above, include silicoflagellates, green algae, and cryptomonad flagellates (Levinton, 2013d).

Multicellular, macroscopic algae, commonly referred to as seaweeds, include green, brown, and red algae. Seaweeds have complex life histories; the stage that is attached to the hard substrate is called a thallus. The thallus may be attached by means of a specialized structure (the holdfast), and further differentiated into a stem-like structure (stipe), and flattened sections (blades or fronds) that are specialized for light capture, whereas other parts are specialized for reproduction or flotation (Levinton, 2013d).

Algae distributions are shaped by water temperature differences that are directed by the Loop Current, Gulf Stream, and North Atlantic Gyre Open Ocean Areas (Spalding et al., 2003). The number of species and proportion of red, brown, and green algae vary along the coast of the Study Area. The overall number of species of red and green algae is higher than brown algae in the warmer waters of the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems. Brown algae species are more common in the colder waters of the Newfoundland-Labrador Shelf, Scotian Shelf, and Northeast U.S. Continental Shelf Large Marine Ecosystems (Dawes, 1998).

Some of the common and ecologically important seaweeds found on shoreline and bottom habitats of the Study Area include the following:

- Sea lettuce (green algae comprising multiple species of *Ulva*) is abundant on intertidal sand and mudflats as well as on rocky shores throughout the Study Area. Sea lettuce is an important food source for fish and invertebrates.
- Rockweeds (brown algae including *Ascophyllum nodosum* and *Fucus* spp.) typically dominate the mid intertidal portions of rocky shores in the inshore waters and open coast of the North Atlantic coast. The rockweed canopy provides a protected habitat for other plants and invertebrates, as well as foraging habitat for fishes at high tide and shorebirds at low tide.
- Kelps (brown algae of the genus *Laminaria*) are dominant on temperate, low intertidal and shallow subtidal rocky shores of the Study Area. Kelp beds are important 3-dimensional habitats for fish and invertebrates.
- Coralline algae (several genera of red algae) incorporate calcite into the thallus — which makes them relatively resistant to grazing — and include both crustose (flat) and foliose (branching) forms. Coralline algae contribute to reef development in tropical environments.

In general, more delicate, highly branched or foliose seaweeds with high surface area are prevalent in low-energy, high-light environments, whereas crustose and robust forms with sturdy thalli and holdfasts are more prevalent in high energy environment (Levinton, 2013d; Peckol & Searles, 1984).

Finally, large areas of the western tropical to subtropical Atlantic and Gulf of Mexico, in both open ocean and coastal regions, are covered with floating mats of *Sargassum* (a brown alga). *Sargassum* mats are an important source of primary production, and constitute a type of Essential Fish Habitat (Gower & King, 2008; Gower et al., 2013; South Atlantic Fishery Management Council, 2002). In recent years, accumulations of *Sargassum* along the Gulf of Mexico coast of the southern United States have led to eutrophication, fish die-offs, and have negatively affected local economies (Doyle & Franks, 2015).

Vascular plants in the Study Area have more limited distributions than algae (which are non-vascular) and typically occur in intertidal to shallow (less than 40 feet [ft.]) subtidal waters, in soft substrate on low-energy (sheltered) shorelines (Green & Short, 2003). Vascular plants that can dominate the vegetation in such areas include seagrasses, cordgrasses, and mangroves, each of which provides a structurally distinct and ecologically important habitat.

The relative distribution of seagrasses is influenced by the availability of suitable substrate occurring in low-wave energy areas at depths that allow sufficient light exposure for growth. Seagrasses as a rule require more light than algae, generally 15 to 25 percent of surface incident light (Fonseca et al., 1998; Green & Short, 2003). Seagrass species distribution is also influenced by water temperatures of the Loop Current, Florida Current, and Gulf Stream (Spalding et al., 2003).

The intertidal, emergent wetland vegetation of salt marshes throughout the Study Area typically includes a middle zone dominated by cordgrasses (*Spartina* spp.), which form dense colonies in coastal lagoons, tidal creeks or rivers, or estuaries, wherever the sediment is adequate to support plant root development (Levinton, 2013e; Mitsch et al., 2009). Other vascular plant species can be dominant below or above the cordgrass zones, or where oligohaline (low salinity) conditions prevail, as in the upper reaches of the inshore waters.

Mangroves and cordgrasses have similar requirements, but mangroves are not tolerant of freezing temperatures. Their occurrence on the Atlantic coast of the United States is concentrated in tropical and subtropical waters with sufficient freshwater input. Refer to Section 3.3.2.3 (Species Not Listed under the Endangered Species Act) for distribution information.

3.3.2.1.2 General Threats

Environmental stressors on marine vegetation are the result of human activities (industrial, residential, and recreational activities) and natural occurrences (e.g., storms, surf, and tides).

Human-made stressors that act on marine vegetation include excessive nutrient input (such as fertilizers), siltation (the addition of fine particles to the ocean), pollution (oil, sewage, trash) (Mearns et al., 2011), climate change (Arnold et al., 2012; Doney et al., 2012; Martinez et al., 2012; Olsen et al., 2012), fishing practices (Mitsch et al., 2009; Steneck et al., 2002), shading from structures, habitat degradation from construction and dredging (National Marine Fisheries Service, 2002), and introduced or invasive species (Hemminga & Duarte, 2000; Spalding et al., 2003; Williams & Smith, 2007). The seagrass, cordgrass, and mangrove taxonomic group is often more sensitive to stressors than the algal taxonomic groups, and their presence in the Study Area has decreased as a result. A review of seagrass from 1879 to 2006 found that global seagrass coverage decreased by 75 percent overall (Waycott et al., 2009). The great diversity of algae makes generalization difficult, but overall, algae are resilient and are able to colonize disturbed environments created by stressors (Levinton, 2013b).

Areas of tidal marsh are also diminished by sinking substrate, a process known as marsh subsidence. Shoreline development can also have fairly severe impacts on coastal wetland habitats, including accelerated erosion, loss of fringing marshes, and increased scouring and turbidity in nearshore waters (Bozek & Burdick, 2005; National Research Council, 2007). Areal coverage of salt marsh typically dominated by cordgrass on the U.S. Atlantic and Gulf of Mexico coasts decreased dramatically during the 20th century, with additional losses of 1 and 1.8 percent on the Atlantic and Gulf coasts, respectively, from 1998 to 2004 (National Oceanic and Atmospheric Administration & U.S. Fish and Wildlife Service, 2008). Likewise, the global mangrove resource decreased by 50 percent from aquaculture, changes in hydrology (water movement and distribution), and sea level rise (Feller et al., 2010).

Each type of vegetation is sensitive to additional unique stressors as discussed below.

3.3.2.1.2.1 Water Quality

Water quality in the Study Area is impacted by sedimentation and turbidity as well as the introduction of harmful contaminants. Common ocean pollutants include toxic compounds such as metals, herbicides, and other organic chemicals; excess nutrients from fertilizers and sewage; detergents; oil; and other solids. Coastal pollution and agricultural runoff may cause toxic red tide events in the Study Area (Hayes et al., 2007). Degraded water quality also has the potential to damage seagrass by stimulating algal growth, which results in negative impacts on seagrass habitat such as shading (Thomsen et al., 2012). The majority of seagrass loss mentioned earlier (Waycott et al., 2009) is attributable to anthropogenic stressors, especially large-scale nutrient enrichment and sedimentation which reduces light penetration to the leaf (Dennison et al., 1993; Orth et al., 2006; Stevenson et al., 1993; Steward & Green, 2007; Twilley et al., 1985).

Oil in runoff from land-based sources, natural seeps, and accidental spills (such as offshore drilling and oil tanker leaks) are some of the major sources of pollution in the marine environment (Levinton, 2013a). The type and amount of oil spilled, weather conditions, season, location, oceanographic conditions, and the method used to remove the oil (containment or chemical dispersants) are some of the factors that determine the severity of the impacts. Sensitivity to oil varies among species and within species, depending on the life stage; generally, early life stages are more sensitive than adult stages (Hayes et al., 1992; Michel & Rutherford, 2013). The tolerance to oil pollutants varies among the types of marine vegetation, but their exposure to sources of oil pollutants makes them all vulnerable.

Oil pollution, as well as chemical dispersants used in response to oil spills, can impact seagrasses directly by smothering the plants, or indirectly by lowering their ability to combat disease and other stressors (Michel & Rutherford, 2013; U.S. National Response Team, 2010). Seagrasses that are totally submerged are less susceptible to oil spills since they largely escape direct contact with the pollutant. Depending on various factors, oil spills can result in a range of effects from no impact to long-lasting impacts, such as decreases in eelgrass density (Kenworthy et al., 1993; Peterson, 2001). Algae are relatively resilient to oil spills, while mangroves are highly sensitive to oil exposure. Contact with oil can cause mangrove death, leaf loss, and failure to germinate (National Oceanic and Atmospheric Administration, 2002). Salt marshes (e.g., cordgrass) can also be severely impacted by oil spills, with long-term effects (Culbertson et al., 2008; Michel & Rutherford, 2013).

3.3.2.1.2.2 Commercial Industries

Seagrasses are uprooted by dredging, scarred by boat propellers (Hemminga & Duarte, 2000; Spalding et al., 2003), and uprooted and broken by anchors (Francour et al., 1999). Seagrass that is uprooted can take years to regrow (Dawes et al., 1997). A variety of commercial development, operations, and activities may impact marine vegetation (e.g., oil/gas development, telecommunications infrastructure, wind energy development, shipping and cruise vessels, commercial and recreational fishing, aquaculture, and eco-tourism) (Crain et al., 2009). Commercial activities are conducted under permits and regulations that require companies to avoid and minimize impacts to sensitive vegetation (e.g., seagrass, emergent wetlands). Commercial and recreational fishing in bays and estuaries directly and indirectly impacts seagrass beds and emergent wetlands in shallow coastal waters of the Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems the Study Area. Physical damage to seagrass beds results from anchoring, propeller scarring, and the deployment of traps, trawl gear, and rakes to harvest fish and invertebrates; seagrass beds are slow to recover from damage. Boat wakes in sheltered inshore waters can erode shorelines and fringing wetlands that would otherwise be relatively stable (Fonseca & Malhotra, 2012; Parnell et al., 2007). Bottom disturbance incidental to fishing also increases turbidity, reducing seagrass establishment, growth, and recovery from disturbance (Blaber et al., 2000).

Sargassum is harvested as an adjunct for a variety of products including medicines, fertilizer, livestock feed and edible seaweed products. Harvesting too much *Sargassum* is a threat to this resource (McHugh, 2003; Trono & Tolentino, 1993). To maintain this resource, *Sargassum* is managed under the Fishery Management Plan for Pelagic *Sargassum* Habitat of the South Atlantic Region due to its importance as Essential Fish Habitat for numerous species (South Atlantic Fishery Management Council, 2002).

Kelp harvesting for edible seaweed is expanding as an industry in New England, raising concerns about the ecological effects of harvesting on the associated marine animals that depend on kelp beds as habitat. Maine has recently developed a rockweed fishery management plan aimed at ensuring the sustainable use of this resource (Maine Department of Marine Resources, 2014).

Finally, intensifying port development overlaps and threatens seagrass meadows in bays and estuaries throughout the world (Benham et al., 2016). Port development is accompanied by development of surrounding areas which tends to increase runoff and sedimentation; the construction of over-water structures that shade the bottom; and dredging, which eliminates shallow water habitat, reduces light availability by increasing turbidity, and also contributes to sedimentation. Shading and sedimentation have been shown to have combined negative effects on seagrass growth, indicating the potential for large-scale impacts to seagrass ecosystems from port development (Benham et al., 2016).

3.3.2.1.2.3 Disease and Parasites

Diseases and parasites are not known to constitute a major threat to marine vegetation at present.

3.3.2.1.2.4 Invasive Species

Invasive species are those that have been introduced into an area and tend to spread rapidly, often aided by disturbed conditions and the absence of natural enemies, causing ecological and/or economic harm (National Ocean Service, 2015). Invasive species are inadvertently discharged in ballast water, arrive in “fouling” communities on boat hulls, and imported through aquaculture and the aquarium trade. Invasive marine species compete with and displace native marine vegetation, whereas invasive invertebrate and fish species impact native marine vegetation through herbivory and more subtly through the alteration of ecological relationships. Changes in marine vegetation caused by invaders have cascading effects on the associated fish and invertebrate communities. The exact number of invasive species in the Study Area is uncertain but is undoubtedly in the hundreds given that at least 64 have been documented in the Gulf of Maine alone (Gulf of Mexico Fishery Management Council, 2010). At least 17 species of non-native marine algae are established in Massachusetts (Massachusetts Office of Coastal Zone Management, 2013).

Examples of invasive species' impacts on vegetation in the Study Area include an invasive seagrass, *Halophila stipulacea*, from the Indian Ocean, that has recently become established in the Eastern Caribbean and is displacing the native seagrass, *Syringodium filiforme* (Willette & Ambrose, 2012). In emergent wetlands, cordgrasses are damaged by storms and have been replaced in many locations along the Atlantic coast in recent decades by an invasive non-native genotype of the common reed (*Phragmites australis*). Whereas the native common reed is restricted to the upper fringes of salt marshes, the non-native genotype spreads throughout the intertidal zone and into freshwater marshes, displacing a variety of emergent wetland plants and altering the structure and function of marsh communities (Levinton, 2013b).

3.3.2.1.2.5 Climate Change

The impacts of anthropogenically induced climate change on the marine environments include rising sea levels, ocean acidification, increased sea temperature, and an increase in severe weather events. All of these changes may have impacts on vegetation in the Study Area. As described by Harley et al. (2006), "Abiotic changes in the environment have direct impacts on dispersal and recruitment, and on individual performance at various stages in the life cycle. Additional effects are felt at the community level via changes in the population size and per capita effects of interacting species. The proximate ecological effects of climate change thus include shifts in the performance of individuals, the dynamics of populations, and the structure of communities. Taken together, these proximate effects lead to emergent patterns such as changes in species distributions, biodiversity, productivity, and microevolutionary processes provide a general model of potential ecological responses to climate change."

The most obvious consequence of sea level rise will be an upward shift in species distributions, but this can only occur along natural or undisturbed shorelines, where the overall photic zone can move upslope with sea level rise. Under such conditions, most species are expected to be able to keep pace with predicted rates of sea level rise, with the exception of some slow-growing, long lived species such as many corals (Knowlton & Kraus, 2001). The effect of sea level rise on bottom illumination is more significant along shorelines with artificial vertical stabilization (e.g., bulkheads, sea walls) that prevent upslope movement of shallow, nearshore habitats (Harley et al., 2006). However, dramatic ecological changes could result from decreased habitat availability within a particular depth zone. For example, intertidal habitat area may be reduced by 20 - 70 percent over the next 100 years in ecologically important North American bays, where steep topography and anthropogenic structures (e.g., sea walls) prevent the inland migration of mudflats and sandy beaches (Galbraith et al., 2005). Sea level rise may also reduce the spatial extent of biogenic habitat by outpacing the accretion rates of marshes and coral reefs (Knowlton & Kraus, 2001; Rabalais et al., 2002).

Rising sea levels will alter the amount of sunlight reaching various areas, which may decrease the photosynthetic capabilities of vegetation in those areas. However, the fast growth and resilient nature of vegetation may enable most species to adapt to these changes (Harley et al., 2006). Increased sea temperature may lead to several impacts that could affect vegetation. Warmer waters may lead to a greater stratification in the water column which may support harmful algal blooms (World Ocean Review, 2015). The stratification may also inhibit upwelling, as seen during El Niño events, which would prevent nutrients from circulating to the surface (Lehmköster, 2015; World Ocean Review, 2015). Additionally, increased sea temperatures may lead to changes in the composition of vegetation communities (Schiel et al., 2004). Increases in severe weather events may lead to increased erosion and sedimentation in the marine environments and higher energy wave action (Coelho et al., 2009).

Vegetation is susceptible to water quality changes from erosion and disturbances from storm events. Increased storm events are expected to have negative impacts on the species diversity in kelp ecosystems (Byrnes et al., 2011). The impacts of ocean acidification on vegetation are poorly understood (Harley et al., 2006).

3.3.2.1.2.6 Marine Debris

Marine debris is any persistent solid material that is manufactured or processed and disposed of or abandoned into the marine environment. This includes materials such as plastic, glass, rubber, metal, as well as derelict (lost or abandoned) fishing gear and vessels, ranging in size from micrometers to meters (National Oceanic and Atmospheric Administration Marine Debris Program, 2016). Emergent wetland vegetation in coastal marshes can trap and concentrate debris, whether disposed of locally or brought in by waves and currents, along natural wrack lines. Heavy debris, such as tires, can physically damage or remove vegetation, and large pieces of plastic can cover the vegetation, reducing photosynthesis and productivity in marshes and submerged aquatic vegetation. Drifting debris can also impact marsh and mangrove productivity by clogging tidal channels and impeding circulation. Derelict fishing gear (especially traps) can tear, break, abrade, and remove submerged aquatic vegetation as it drifts along the bottom in shallow water. The severity of debris impacts is related to the type of debris, proximity to debris sources, and physical conditions that concentrate and lead to the accumulation of debris. Although marine debris impacts on vegetation are likely widespread, the magnitude (extent, and duration) of such impacts on vegetation communities and the associated fauna are poorly understood (National Oceanic and Atmospheric Administration Marine Debris Program, 2016).

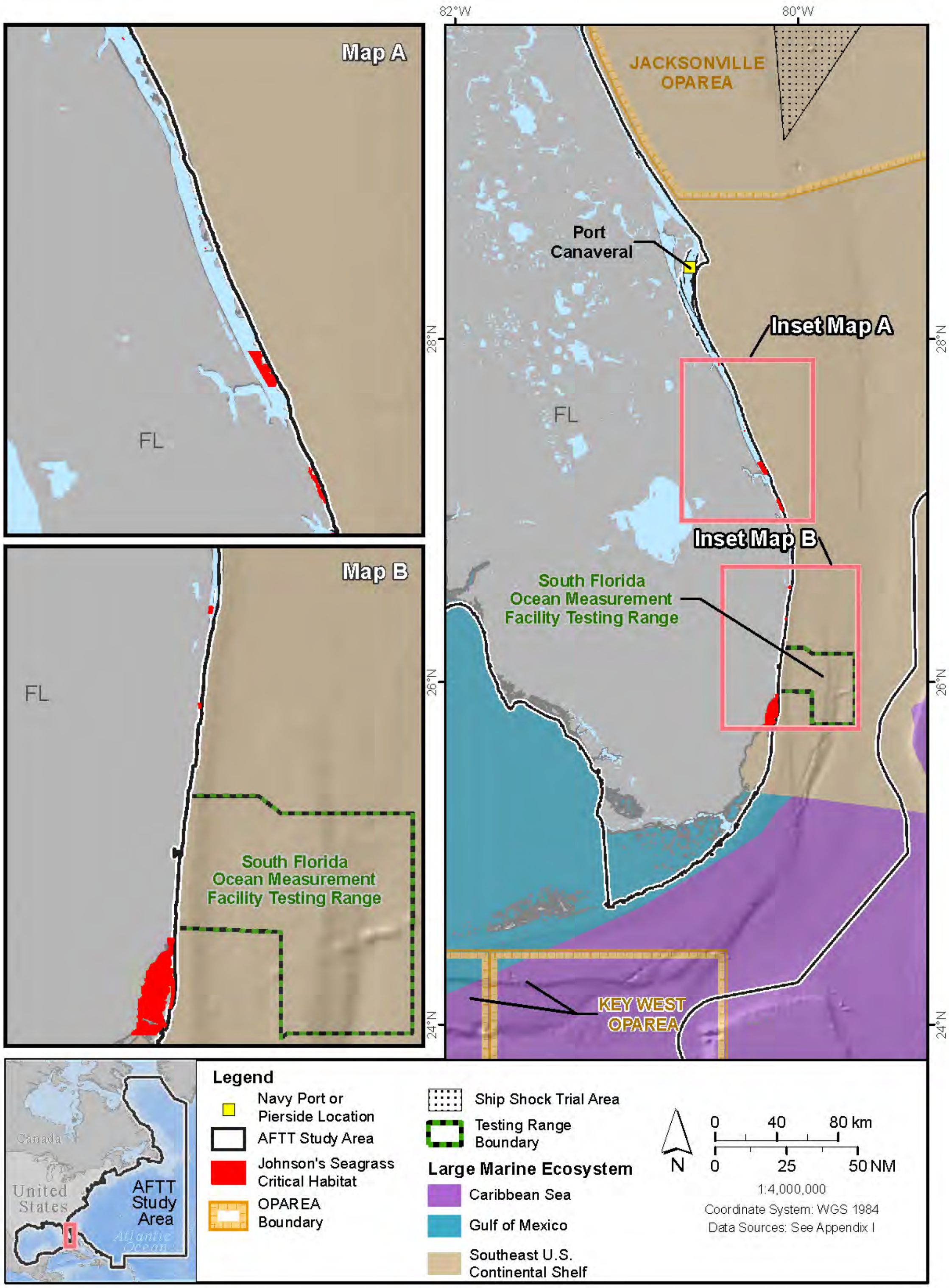
3.3.2.2 Endangered Species Act-Listed Species

One species of vegetation federally listed as endangered, threatened, candidate, or proposed under the ESA potentially occurs in the Study Area. That species, Johnson's seagrass (*Halophila johnsonii*) (listed as threatened), is described below.

3.3.2.2.1 Johnson's Seagrass (*Halophila johnsonii*)

3.3.2.2.1.1 Status and Management

In 1998, Johnson's seagrass was the first marine plant species to be designated as federally threatened under the ESA by NMFS (*Federal Register* 63[117]: 49035-49041, September 14, 1998). In 2000, 10 areas in Southeast Florida were designated as critical habitat (*Federal Register* 65[66]: 17786-17804, April 5, 2000); see Figure 3.3-1. The general physical and biological features of the critical habitat areas are "adequate water quality, salinity levels, water transparency, and stable, unconsolidated sediments that are free from physical disturbance" (*Federal Register* 65[66]: 17786-17804, April 5, 2000). Designated critical habitat areas also fulfill one or more of the following five criteria (*Federal Register* 65[66]: 17786-17804, April 5, 2000):



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

Figure 3.3-1: Designated Critical Habitat Areas for Johnson's Seagrass Adjacent to the Study Area

- locations with populations that have persisted for 10 years,
- locations with persistent flowering plant populations,
- locations at the northern and southern range limits of the species,
- locations with unique genetic diversity, and
- locations with a documented high abundance of Johnson's seagrass compared to other areas in the species' range.

3.3.2.2.1.2 Habitat and Geographic Range

The preferred habitat for Johnson's seagrass is coastal lagoons and bays, from the area covered at high tide to depths of up to 3 m (National Marine Fisheries Service, 2002). It is found year-round in sediments of loose sand and silt-clay in beds with other species of seagrass (Creed et al., 2003; Eiseman & McMillan, 1980).

Johnson's seagrass has a discontinuous and patchy distribution along the Southeast coast of Florida in the Southeast U.S. Continental Shelf Large Marine Ecosystem. This species is not found in any other large marine ecosystem or in any open ocean areas. It is reported to occur between 11.5 nautical miles (NM) north of Sebastian Inlet (Indian River Lagoon) and Biscayne Bay on the Southeast coast of Florida in lagoons and bays (Florida Department of Environmental Protection, 2010a; National Marine Fisheries Service, 2002). Although the geographic range of the species overlaps the Study Area, designated critical habitat areas do not; they are more limited and occur in parts of the Indian River Lagoon and Biscayne Bay in Florida (Figure 3.3-1). A recent study reported Johnson's seagrass north of Sebastian Inlet, which extends the northern limit of this species by 11.5 (NM); the extension is considered temporary and only expected to occur under favorable conditions (Virnstein & Hall, 2009).

No training or testing activities are proposed in the lagoons or bays where Johnson's seagrass occurs and they do not overlap with the critical habitat of this species. The naval facilities at Port Canaveral and the South Florida Ocean Measurement Facility Testing Range are the closest Navy training and testing areas to the distribution of Johnson's seagrass. Taking the northern extension into consideration, the northern limit for Johnson's seagrass is estimated to be 22 NM away from Port Canaveral. The South Florida Ocean Measurement Facility Testing Range is less than 2 NM away from Johnson's seagrass critical habitat.

3.3.2.2.1.3 Population Trends

There are an estimated 502,000 acres (ac) of Johnson's seagrass between Sebastian Inlet and Biscayne Bay, Florida (Florida Department of Environmental Protection, 2010a; National Marine Fisheries Service, 2002). Population and abundance trends for this species are difficult to approximate due to its fairly recent identification as a distinct species (Eiseman & McMillan, 1980), short-lived nature, and rareness of quantitative population data (Creed et al., 2003; National Marine Fisheries Service, 2002; Virnstein et al., 2009). Since the 1970s, seagrass species have decreased by approximately 50 percent in the Indian River Lagoon, which constitutes a large part of the range for Johnson's seagrass (Woodward-Clyde Consultants, 1994). This decline of seagrasses in the Indian River Lagoon was likely due to human impacts on water quality and marine substrates (Woodward-Clyde Consultants, 1994). Compared to other seagrasses within its range in the Indian River area (Hobe Sound, Jupiter Sound, and Fort Pierce Inlet), Johnson's seagrass is the least abundant (Virnstein et al., 1997; Virnstein & Hall, 2009).

3.3.2.2.1.4 Species-Specific Threats

Johnson's seagrass is vulnerable to the threats to seagrasses discussed in Section 3.3.2.1.2 (General Threats). This species is especially vulnerable to these threats because of its limited distribution and reproductive capability (no seed production), which result in its limited potential for recovery (National Marine Fisheries Service, 2002).

3.3.2.3 Species Not Listed Under the Endangered Species Act

Vegetation within the Study Area is comprised of many thousands of species of plants spanning many taxonomic groups (taxonomy is a method of classifying and naming organisms). For this analysis, vegetation has been divided into eight major taxonomic groups, referred to as phyla (plural of phylum), that have distinct morphological, biochemical, physiological, and life history traits that reflect their evolutionary history and influence their distributions and ecological relationships Table 3.3-1 below provides general descriptions of these major vegetation groups in the Study Area and their vertical distributions. Subsections following Table 3.3-1 describe these groups in more detail. The distribution and condition of abiotic (non-living) substrate associated with habitats for attached macroalgae and rooted vascular plants (e.g., seagrass), and the impact of stressors are described in Section 3.5 (Habitats).

Table 3.3-1: Major Groups of Vegetation in Study Area

Major Vegetation Groups		***Distribution within Study Area[2]***		
Common Name[1] (Taxonomic Group)	***Description***	***Open Ocean***	***Large Marine Ecosystem***	***Inshore Waters***
Blue-green algae (phylum Cyanobacteria)	Photosynthetic bacteria that are abundant constituents of phytoplankton and benthic algal communities, accounting for the largest fraction of carbon and nitrogen fixation by marine vegetation; existing as single cells or filaments, the latter forming mats or crusts on sediments and reefs.	Water column	Water column, bottom	Water column, bottom
Dinoflagellates (phylum Dinophyta [Pyrrophyta])	Most are single-celled, marine species of algae with two whip-like appendages (flagella). Some live inside other organisms, and some produce toxins that can result in red tide or ciguatera poisoning.	Water column	Water column	Water column
Green algae (phylum Chlorophyta)	May occur as single-celled algae, filaments, and seaweeds.	None	Water column, bottom	Water column, bottom
Coccolithophores (phylum Haptophyta [Chrysophyta, Prymnesiophyceae])	Single-celled marine phytoplankton that surround themselves with microscopic plates of calcite. They are abundant in the surface layer and are a major contributor to global carbon fixation.	Water column	Water column	Water column

Table 3.3-1: Major Groups of Vegetation in Study Area (continued)

Major Vegetation Groups		*Distribution within Study Area[2]*		
Common Name[1] (Taxonomic Group)	***Description***	***Open Ocean***	***Large Marine Ecosystem***	***Inshore Waters***
Diatoms (phylum Ochrophyta [Heterokonta, Chrysophyta, Bacillariophyceae])	Single-celled algae with a cylindrical cell wall (frustule) composed of silica. Diatoms are a primary constituent of the phytoplankton and account up to 20 percent of global carbon fixation.	Water column	Water column, bottom	Water column, bottom
Brown algae (phylum Phaeophyta [Ochrophyta])	Brown algae are large multi-celled seaweeds that include vast floating mats of *Sargassum*.	Water column	Water column, bottom	Water column, bottom
Red algae (phylum Rhodophyta)	Single-celled algae and multi-celled large seaweeds; some form calcium deposits.	Water column	Water column, bottom	Water column, bottom
Vascular plants (phylum Tracheophyta)	Includes seagrasses, cordgrass, mangroves and other rooted aquatic and wetland plants in marine and estuarine environments, providing food and habitat for many species.	None	Bottom	Bottom

Notes: [1]Taxonomic groups are based on Roskov et al. (2015); (Ruggiero & Gordon, 2015). Alternative classifications are in brackets []. Phylum and division may be used interchangeably.
[2]Vertical distribution in the Study Area is characterized by open ocean oceanographic features (Labrador Current, Gulf Stream, and North Atlantic Gyre) or by coastal waters of large marine ecosystems (Caribbean Sea, Gulf of Mexico, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, and West Greenland Shelf).

3.3.2.3.1 Blue-Green Algae (Phylum Cyanobacteria)

Blue-green algae are photosynthetic bacteria that include single-celled and filamentous forms that inhabit the lighted surface water and seafloor of the world's oceans (Roskov et al., 2015). Like other bacteria, they are *prokaryotes* – their cells lack internal membrane-bound organelles such as a nucleus and they do not reproduce by mitosis. The remaining groups of plants discussed below are *eukaryotes* – whose cells have internal organelles and reproduce by mitosis. Blue-green algae are important primary producers, accounting for much of the carbon (and nitrogen) fixation and oxygen production in the ocean. More than 1,000 species of blue-green algae occur in the Study Area (Castro & Huber, 2000). Blue-green algae are an important food source for both zooplankton (free-floating animals) and grazing organisms (e.g., molluscs: chitons and limpets) on the seafloor. Blue-green algae occur in all large marine ecosystems, open ocean areas, and inshore waters (e.g., lower Chesapeake Bay, Narragansett Bay, and St. Andrew Bay) of the Study Area. Common species of blue-green algae that occur in the Study Area are *Microcystis aeruginosa* and members of the genus *Synechococcus*.

3.3.2.3.2 Dinoflagellates (Phylum Dinophyta)

Dinoflagellates are single-celled, predominantly marine algae (Roskov et al., 2015). Together with diatoms and coccolithophorids, they constitute the majority of marine eukaryotic phytoplankton (Marret & Zonneveld, 2003). Thousands of species live in the surface waters of the Study Area (Castro & Huber, 2000). Most dinoflagellates are photosynthetic, and many can also ingest small food particles. They occur in all large marine ecosystems, open ocean areas, and inshore waters of the Study Area.

Photosynthetic dinoflagellate symbionts (zooxanthellae) live inside corals and are essential to calcification and reef-building. Organisms such as zooplankton feed on dinoflagellates. Some dinoflagellates produce toxins and are responsible for some types of harmful algal blooms caused by sudden increases of nutrients (e.g., fertilizers) from land into the ocean or changes in temperature and sunlight (Levinton, 2013a). Additional information on harmful algal blooms can be accessed on the Centers for Disease Control and the National Oceanic and Atmospheric Administration websites. Common species of dinoflagellates that occur in the Study Area are *Polysphaeridium zoharyi* and *Tectatodinium pellitum* (Marret & Zonneveld, 2003).

3.3.2.3.3 Green Algae (Phylum Chlorophyta)

Green algae include single-celled and multi-celled types that form sheets or branched structures (Roskov et al., 2015). These multi-celled types of green algae are referred to as macroalgae (seaweed) (National Oceanic and Atmospheric Administration, 2011). Hundreds of marine species of green algae are common in well-lit, shallow water. Green seaweeds, like most macroalgae, are found attached to hard to intermediate (gravel to cobble-sized particles) substrate throughout the Study Area, although some species occur on firm sand and mud (Levinton, 2013a). Other types of green single-celled algae are planktonic (float freely in the ocean) and are found in the surface waters of the open ocean areas of the Study Area in addition to the areas where the macroalgae occur. Green algae species are eaten by various organisms, including zooplankton and snails. Some common species of green algae that occur in the Study Area are sea lettuce (*Ulva lactuca*) and members of the genus *Enteromorpha*.

3.3.2.3.4 Coccolithophores (Phylum Haptophyta)

Coccolithophores are single-celled phytoplankton that are especially abundant in tropical oceans but also bloom seasonally at higher latitudes. They are nearly spherical and covered with plates made of calcite (calcium carbonate) which account for approximately one-third of calcium carbonate production in the ocean. They are an often abundant component of the phytoplankton and account for a large fraction of primary production and carbon sequestration in the ocean. Blooms produce a strong bluish-white reflection that may cover thousands of square miles (Levinton, 2013b).

3.3.2.3.5 Diatoms (Phylum Ochrophyta)

Diatoms are primarily planktonic (although many species are benthic), single-celled organisms with cell walls made of silica (Castro & Huber, 2000). Approximately 6,000 species of marine diatoms are known. Diatoms occur in the lighted areas - the upper 200 m (see Figure 3.0-3 in Section 3.0.2.2, Bathymetry) – of the water column and benthic habitat throughout the Study Area. Diatoms also contribute significantly to the long-term sequestration of carbon in the oceans and are a major food source for zooplankton. The silica content of diatom cells has been shown to significantly affect zooplankton grazing, growth, and reproduction rates; rates are reduced when silica content is higher (Liu et al., 2016).

3.3.2.3.6 Brown Algae (Phylum Phaeophyta)

Brown algae are predominately marine species with structures varying from fine filaments to thick leathery forms (Castro & Huber, 2000). Most species are attached to the seafloor in coastal waters although a free-floating type of brown algae, *Sargassum* (*Sargassum* spp.) occurs in the Study Area. Another major type of brown macroalgae that occurs in the Study Area is kelp (*Laminaria* spp.). Kelp and *Sargassum* are discussed in more detail below.

3.3.2.3.6.1 Kelp

Kelp is a general term that refers to brown algae of the order Laminariales. Kelp plants are made of three parts: the leaf-like blade(s), the stipe (a stem-like structure), and the holdfast (a root-like structure that anchors the plant to the bottom). Kelps are represented by three macroalgae species in the Study Area: *Laminaria saccharina, Laminaria longicruris*, and *Laminaria digitata* (Egan & Yarish, 1988). These species are prostrate; their blades form low beds covering the bottom (Steneck et al., 2002). Kelp are anchored to hard surfaces on the seafloor (Levinton, 2013b). These kelp species occur from the low tide line out to depths as great as 65 ft. (20 m) depending on the water clarity (Luning, 1990; Steneck et al., 2002) along the rocky, northwest Atlantic shores in large subtidal stands where sufficient nutrients are available (Vadas et al., 2004). In the Study Area, *Laminaria* spp. occur from Greenland to Long Island in the Newfoundland-Labrador Shelf and Scotian Shelf Large Marine Ecosystems, and in the northern part of the Northeast U.S. Continental Shelf Large Marine Ecosystem (Mathieson et al., 2009; Steneck et al., 2002). In Long Island Sound, one of the most extensive kelp beds, consisting of *Laminaria longicuris*, is at Black Ledge, Groton, Connecticut, just offshore of the Thames River Estuary. Growth rates of 1 inch (in.) (2.5 centimeters [cm]) per day were measured at this location, which is also at the southern limit for kelp in the Study Area (Egan & Yarish, 1990).

The primary productivity and structural complexity of kelp forests support diverse communities of fish and invertebrates. In addition, kelp beds are extremely important in moderating the effects of wave action on shorelines. Organisms such as sea urchins and crustaceans feed on kelp (Steneck et al., 2002).

3.3.2.3.6.2 *Sargassum*

The dominant open ocean species of *Sargassum* in the Study Area are *Sargassum natans* and *Sargassum fluitans*. These species float freely on the sea surface and grow in clumps and mats (Coston-Clements et al., 1991). Accumulations of *Sargassum* are vital to some species and economically important to commercial fisheries and other industries. It provides foraging areas and habitat for marine organisms (e.g., sea turtles, birds, and fish) and raw materials for fertilizers and medicines (South Atlantic Fishery Management Council, 2002). Designated critical habitat for loggerhead sea turtles (*Caretta caretta*) includes *Sargassum* habitat, defined as developmental and foraging habitat for young loggerheads where surface waters form accumulations of floating material, especially *Sargassum* (50 CFR Part 226). See Sections 3.6 (Fishes), 3.7 (Marine Mammals), 3.8 (Reptiles), and 3.9 (Birds and Bats), for more information.

Over-harvesting of *Sargassum* is a threat to this resource (McHugh, 2003; Trono & Tolentino, 1993). To maintain this resource, *Sargassum* is managed under the Fishery Management Plan for Pelagic *Sargassum* Habitat of the South Atlantic Region due to its importance as Essential Fish Habitat for numerous species (South Atlantic Fishery Management Council, 2002).

In the Study Area, *Sargassum* is widely distributed in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems, and in the Gulf Stream and North Atlantic Gyre Open Ocean Areas. In the North Atlantic, *Sargassum* occurs mainly within the physical bounds of the North Atlantic Gyre Open Ocean Area (see Figure 3.0-1), between latitudes 20 degrees (°) N and 40° N, and between longitude 30° W and the western edge of the Gulf Stream—a region known as the Sargasso Sea (Gower et al., 2006; South Atlantic Fishery Management Council, 2002). Some exchange occurs among the *Sargassum* populations in the Caribbean Sea, Gulf of Mexico, and the North Atlantic. Recent satellite image evidence suggests that *Sargassum* originates in the northwest Gulf of Mexico every spring and is moved into the Atlantic east of Cape Hatteras in late summer by the Loop Current and Gulf Stream, and later appears Northeast of the Bahamas in the beginning of the next year (Gower & King, 2008). See Section 3.0.2.3 (Currents, Circulation Patterns, and Water Masses) for more information on the Loop Current and Gulf Stream.

The difficulty of tracking and sampling *Sargassum* makes acquiring information about its distribution and abundance difficult. Estimates based on towed net samples for the North Atlantic range from 4.4 to 12 million U.S. tons (Butler et al., 1983; South Atlantic Fishery Management Council, 2002). A more recent estimate based on satellite imaging data puts the average total mass of *Sargassum* at 2 million U.S. tons in the Gulf of Mexico and the Atlantic (1 million U.S. tons in each) (Gower & King, 2008). Using the low and high abundance estimates (2 million U.S. tons to 12 million U.S. tons) and a conversion factor of 25 grams per square meter of *Sargassum* (Gower et al., 2006), approximately 21,000 square nautical miles (NM^2) to 130,000 NM^2 of the Study Area is covered by *Sargassum*. Given the size of the Study Area (approximately 2.6 million NM^2), the relative coverage of *Sargassum* ranges from less than 1 percent to 5 percent of the sea surface.

3.3.2.3.7 Red Algae (Phylum Rhodophyta)

Red algae are predominately marine, with approximately 4,000 species of microalgae worldwide (Castro & Huber, 2000). Red macroalgae species have various forms from fine filaments to thick calcium carbonate crusts and require a surface to attach to such as hard bottom or another plant. Red macroalgae and some microalgae species are found attached to the seafloor or on sediment, respectively, in all of the large marine ecosystems and the inshore waters of the Study Area (Adey & Hayek, 2011; Levinton, 2013b). Planktonic microalgae are present in the surface waters of the open ocean areas of the Study Area in addition to the areas where the macroalgae occur. Some common species of red algae that occur in the Study Area are in the genus *Lithothamnion* (crustose coralline algae). Red algae are a food source for various zooplankton, sea urchins, fishes, and chitons.

3.3.2.3.8 Seagrasses, Cordgrasses, and Mangroves (Phylum Spermatophyta)

3.3.2.3.8.1 Seagrasses

Seagrasses are unique among flowering plants in their ability to grow submerged in shallow marine environments. Seagrasses grow predominantly in shallow, subtidal, or intertidal sediments sheltered from wave action in estuaries, lagoons, and bays (Phillips & Meñez, 1988) and can extend over a large area to form seagrass beds (Garrison, 2004; Gulf of Mexico Program, 2004; Phillips & Meñez, 1988). Seagrasses, including ESA-listed Johnson's seagrass, serve as a food source for numerous species (e.g., green sea turtles, West Indian manatees, and various plant-eating fishes) (Heck et al., 2003; National Marine Fisheries Service, 2010). Seagrasses also constitute Essential Fish Habitat for managed fisheries and are important as nursery habitat for juvenile stages along the eastern seaboard (South Atlantic Fishery Management Council, 2009). Seagrass meadows may provide an "acoustic refuge" for fish by impeding the transmission of high-frequency clicks used by bottlenose dolphins to detect fish, while enhancing the transmission of low-frequency sounds used in fish communication (Wilson et al., 2013).

Seagrasses occur in all Atlantic and Gulf of Mexico coastal states, except for Georgia and South Carolina (Fonseca et al., 1998). In the Study Area, seagrasses grow from the intertidal zone to a maximum depth of 295 ft. (90 m) as reported for *Halophila engelmannii* in the clear, protected waters off southern Florida (Ferguson & Wood, 1994; Florida Department of Environmental Protection, 2010b; Fourqurean et al., 2002; Green & Short, 2003; Gulf of Mexico Program, 2004).

Depth limits for seagrasses in inshore portions of the Study Area are 6 m in Narragansett Bay (Narragansett Bay Estuary Program, 2010), 1 m in Chesapeake Bay (Orth & Moore, 1988), and 2.4 m in St. Andrew Bay (Florida Department of Environmental Protection, 2010b). The largest area of seagrass in the Study Area occurs in the Gulf of Mexico Large Marine Ecosystem, followed by the Southeast U.S. Continental Shelf, and the Northeast U.S. Continental Shelf Large Marine Ecosystems (see Figure 3.3-2 through Figure 3.3-4 and Table 3.3-2) (Spalding et al., 2003). The vast majority of the mapped seagrass area is located within inshore waters or very close to shore in the nearshore-estuarine environment; unvegetated beaches or vegetated rocky shores border the vast majority of the oceanic/marine portion of the Study Area.

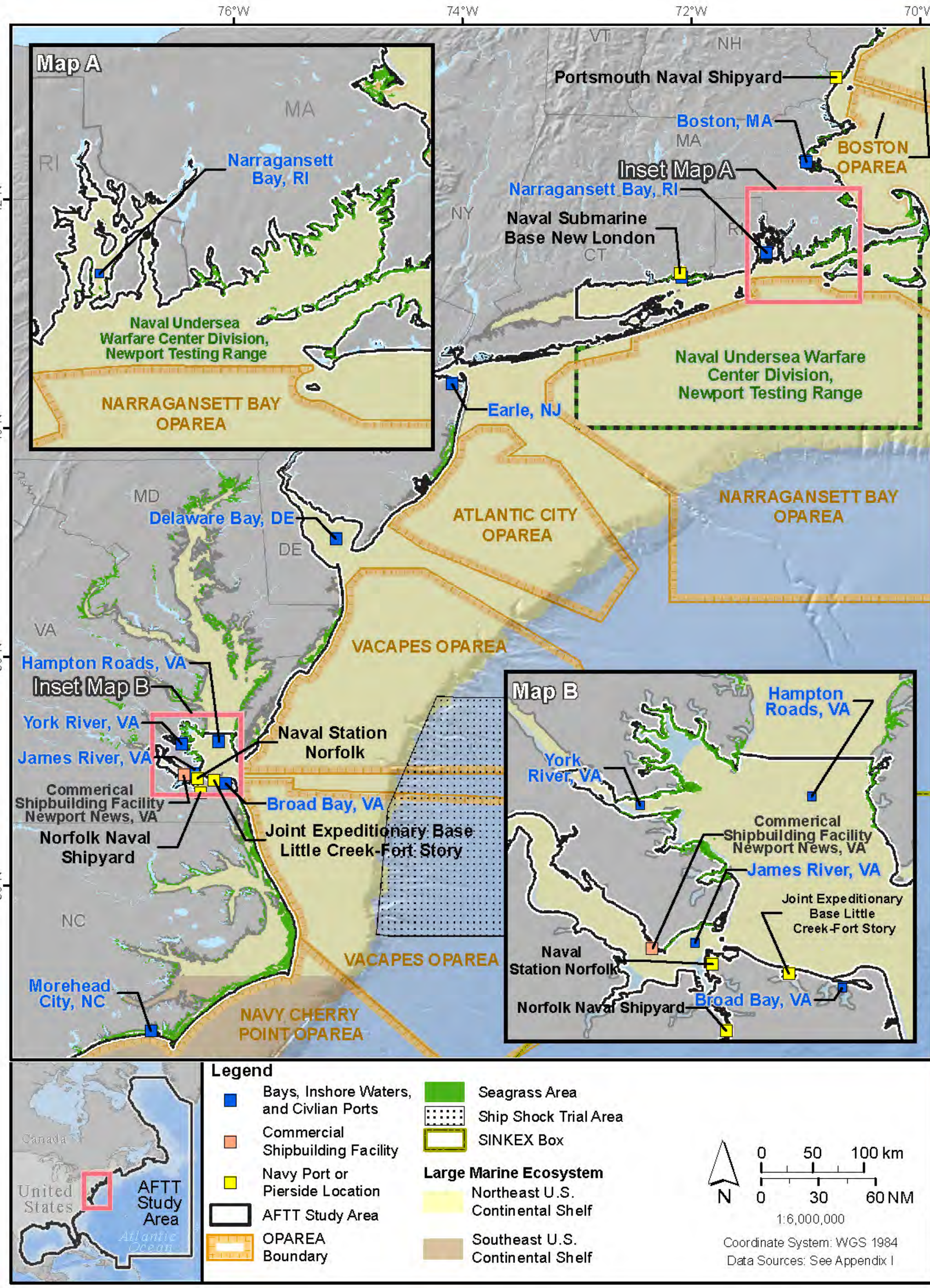
Table 3.3-2: Presences of Seagrass Species within the Study Area

Seagrass Species	***Presence in the Study Area[1]***
Clover grass (*Halophila baillonii*)	Gulf of Mexico, Caribbean Sea
Eelgrass (*Zostera marina*)	West Greenland Shelf, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf
Engelmann's seagrass (*Halophila engelmannii*)	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea
Johnson's seagrass (*Halophila johnsonii*)	Southeast U.S. Continental Shelf
Manatee grass (*Syringodium filiforme*)	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea
Paddle grass (*Halophila decipiens*)	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea
Shoal grass (*Halodule wrightii*)	Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea
Turtlegrass (*Thalassia testudinum*)	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea
Widgeon grass (*Ruppia maritima*)	Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea

Note(s): [1]Presence in the Study Area indicates the coastal waters of large marine ecosystems (Gulf of Mexico, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Caribbean Sea, Scotian Shelf, Newfoundland-Labrador Shelf, and West Greenland Shelf) in which the species are found.
Source(s): Spalding et al. (2003)

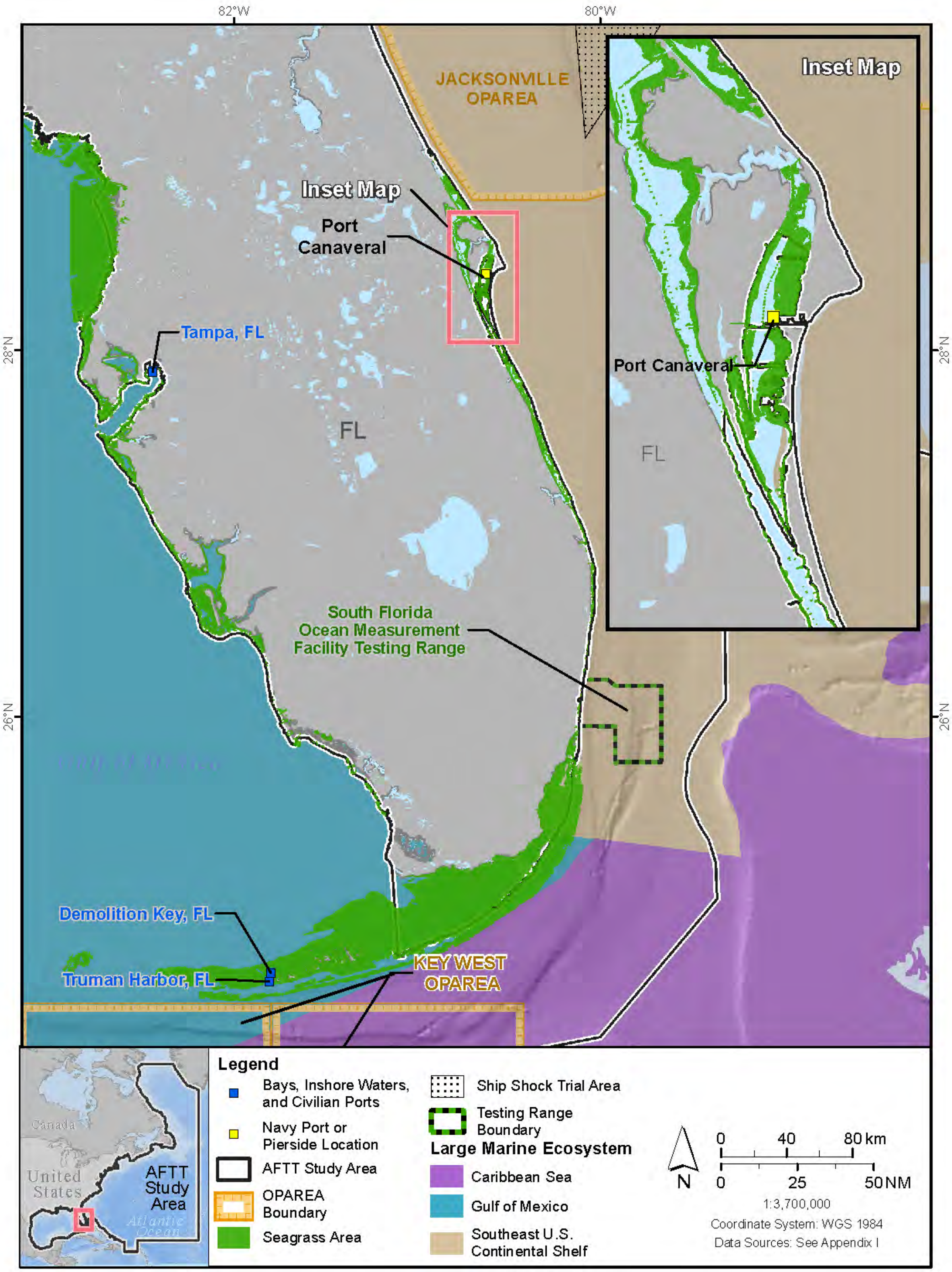
3.3.2.3.8.2 Cordgrasses

The most common plant species of salt and brackish marshes in the Study Area is known as smooth or salt marsh cordgrass (*Spartina alterniflora)* (Mitsch et al., 2009). Cordgrasses and other emergent wetland species are salt-tolerant, moderate-weather (temperate) species and an integral component of salt and brackish marsh vegetation in the Study Area. Salt and brackish marshes develop in intertidal, protected low-energy environments, usually in coastal lagoons, tidal creeks or rivers, or estuaries. The difference between salt and brackish marsh is based on salinity, reflecting the amount of freshwater inflow: salt marshes have salinities of 18 - 30 parts per thousand (ppt), whereas brackish marshes have salinities of 0.5 -18 ppt (Mitsch et al., 2009). Brackish marshes occur where there is freshwater inflow, i.e., in the inshore waters of the Study Area. Brackish marsh dominants include other species of cordgrass (*Spartina* spp.), giant reed (*Phragmites australis*), cattails (*Typha* spp.), and bulrushes (*Bolboschoenus* and *Schoenoplectus* spp.) (Beckett et al., 2016; Massachusetts Natural Heritage and Endangered Species Program, 2016; Pennings et al., 2012; U.S. Fish and Wildlife Service, 1999).



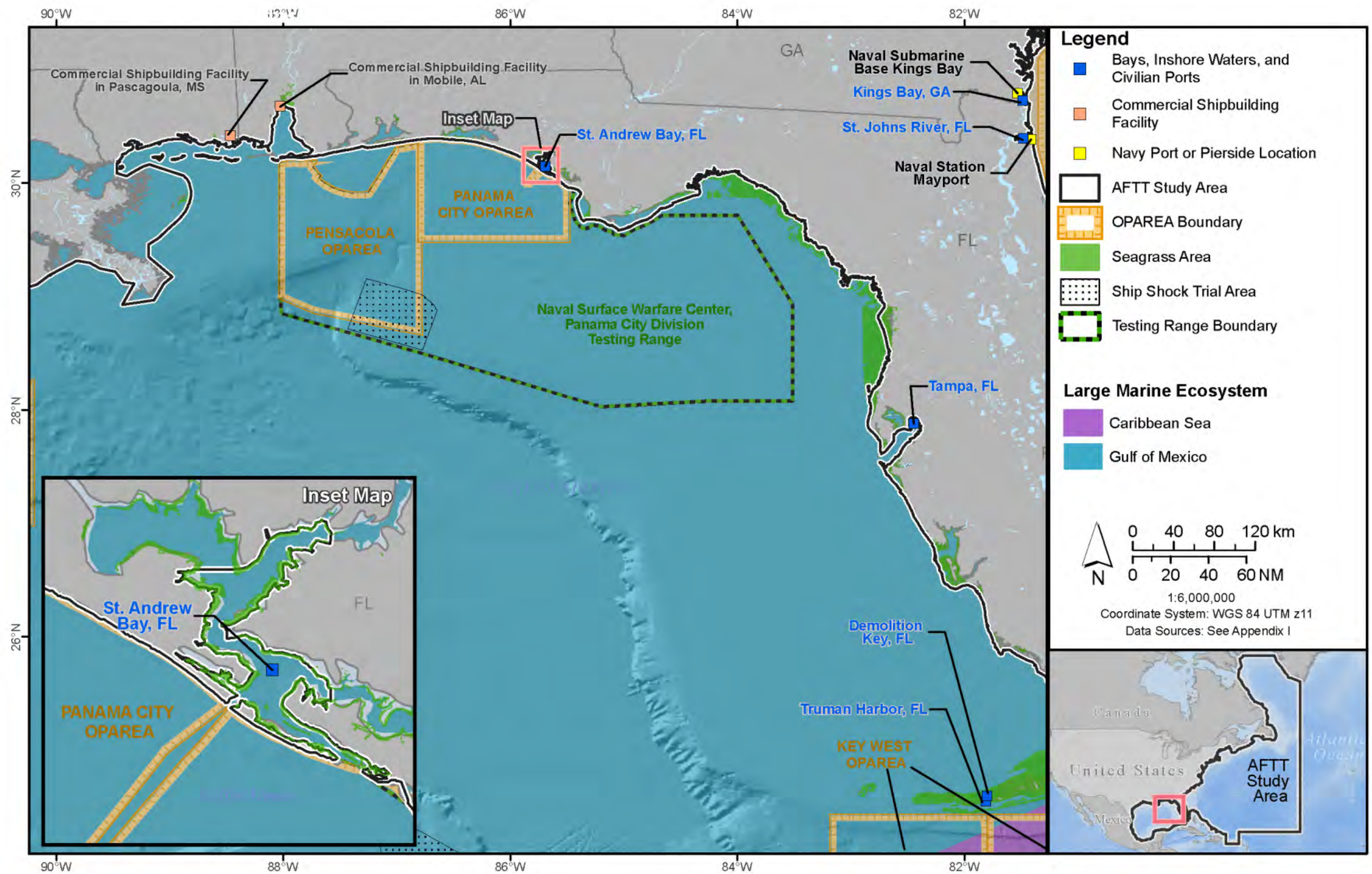
Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Ship Sinking Exercise; VACAPES: Virginia Capes

Figure 3.3-2: Seagrass Occurrence in Mid-Atlantic and New England



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

Figure 3.3-3: Seagrass Occurrence in South Florida



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

Figure 3.3-4: Seagrass Occurrence in the Gulf of Mexico

Salt and brackish marshes are the dominant coastal wetland types along much of the Atlantic and Gulf Coasts of the United States. Cordgrasses occur in salt marshes from Maine to Florida, and along the Gulf of Mexico from Louisiana to Texas (Mitsch et al., 2009). On shorelines bordering the Study Area, the largest areas of cordgrass-dominated salt marsh are in the Gulf of Mexico Large Marine Ecosystem, covering an estimated 2,498,225 ac (1,011,000 hectares [ha]), while an additional 1,653,130 ac (669,000 ha) of salt marsh occurs in the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems (Watzin & Gosselink, 1992). The vast majority of marsh shoreline, however, is located within inshore waters along soft shorelines, mostly outside of the Study Area, e.g., upstream in tidal creeks and on the upper part of the shore. Beaches or rocky shores border the vast majority of the oceanic portion of the Study Area (Spalding et al., 2003).

3.3.2.3.8.3 Mangroves

Mangroves are a group of woody plants that have adapted to estuarine environments (where salt water and freshwater mix) (Ruwa, 1996). Mangroves inhabit marshes and mudflats in tropical and subtropical areas. Within the Study Area, three mangrove species occur in the Southeast U.S. Continental Shelf and Gulf of Mexico Large Marine Ecosystems (Table 3.3-3). Mangroves occur from Cedar Key to Cape Canaveral, Florida (Mitsch et al., 2009). The northern limit for mangroves in Florida is St. Augustine. The largest continuous tract of mangrove forest in the Study Area is found in the Florida Everglades system (U.S. Geological Survey, 2003).

Table 3.3-3: Presence of Mangrove Species in the Study Area

Mangrove Species	*Presence in the Study Area*[1]
Red mangrove (*Rhizophora mangle*)	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea
Black mangrove (*Avicennia germinans*)	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea
White mangrove (*Laguncularia racemosa*)	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea

Sources: (Ellison et al., 2007a, 2007b, 2007c)
Notes: [1]Presence in the Study Area indicates the coastal waters of large marine ecosystems (Gulf of Mexico, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Caribbean Sea, Scotian Shelf, Newfoundland-Labrador Shelf, and West Greenland Shelf) in which the species are found.

3.3.3 Environmental Consequences

This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives) potentially impact vegetation known to occur within the Study Area. Tables 2.6-1 through 2.6-4 present the baseline and proposed typical training and testing activity locations for each alternative (including number of annual events). General characteristics of all Navy stressors were introduced in Section 3.0.3.3 (Identifying Stressors for Analysis), and the susceptibility to stressors for living resources were introduced in Section 3.0.3.6 (Biological Resource Methods). The stressors vary in intensity, frequency, duration, and location within the Study Area. Each stressor is discussed below, and those that are applicable (having potential impacts) to vegetation are listed below and analyzed for impacts.

- **Explosives** (explosions in-air, explosions in-water)
- **Physical disturbance and strikes** (vessels and in-water devices, aircraft and aerial targets, military expended materials, seafloor devices, pile driving)
- **Secondary stressors** (impacts to habitat, impacts to prey availability)

The analysis includes consideration of the mitigation that the Navy will implement to avoid potential impacts on vegetation from explosives and from physical disturbance and strikes.

3.3.3.1 Acoustic Stressors

There is no evidence that underwater acoustic stressors impact marine vegetation. Acoustic stressors therefore are not applicable and will not be analyzed in this section.

3.3.3.2 Explosive Stressors

3.3.3.2.1 Impacts from Explosives

Various types of explosives are used during training and testing activities. The type, number, and location of activities that use explosives are described in Section 3.0.3.3.2 (Explosive Stressors) and the resulting footprints on bottom habitats are quantified in Appendix F (Military Expended Materials and Direct Strike Impact Analysis) and summarized in Section 3.5 (Habitats). Most detonations would occur in waters greater than 200 ft. in depth and more than 3 NM from shore.

The potential for an explosion to injure or destroy vegetation would depend on the amount of vegetation present, the number of munitions used, and their net explosive weights. In areas where vegetation and locations for explosions overlap, vegetation on the surface of the water, in the water column, or rooted in the seafloor may be impacted.

Single-celled algae likely overlap with underwater and sea surface explosion locations. If single-celled algae are in the immediate vicinity of an explosion, only a small number of them are likely to be impacted relative to their total population-level. Additionally, the extremely fast growth rate and ubiquitous distribution of phytoplankton (Caceres et al., 2013; Levinton, 2013b) suggest no meaningful impact on this resource. The low number of explosions in the water column relative to the amount of single-celled algae in the Study Area also decreases the potential for impacts. The impact on single-celled algae populations would not be detectable; therefore, it will not be discussed further.

Macroalgae attached to the seafloor, floating *Sargassum,* and seagrasses may all occur in locations where explosions are conducted and may be adversely impacted for different reasons. Much of the attached macroalgae grows on hard bottom areas and artificial structures.

Attached macroalgae grow quickly and are resilient to high levels of wave action (Mach et al., 2007), which may aid in their ability to recover from and withstand wave action caused by underwater explosions near them on the seafloor. Floating *Sargassum* is more resilient to physical disturbance than seagrass, but there are more explosions on or near the surface where they co-occur. Seagrasses (i.e., submerged aquatic vegetation) take longer to recover from physical disturbance than macroalgae, but activities involving explosions on the seabed will not be conducted within a 350-yd. radius of submerged aquatic vegetation, with the exception of designated locations such as Truman Harbor and Demolition Key (in the Key West Range Complex), where these resources will be avoided to the maximum extent practicable (Table 5.4-1). Neither the ESA-listed species Johnson's seagrass, nor its critical habitat, overlap areas that would be subject to impacts from explosives.

Attached macroalgae typically need hard or artificial substrate in order to grow. The potential distribution of attached macroalgae can be inferred by the presence of hard or artificial substrate that occurs at depths of less than 200 m throughout the Study Area, although most macroalgae growth and kelp in, particular, in the Study Area occurs at depths less than about 45 m, depending on water clarity, temperature, and nutrients (Peckol & Ramus, 1988). See Section 3.5 (Habitats) for information regarding the distribution of hard substrate in the Study Area. Calculations in Appendix F (Military Expended Materials and Direct Strike Calculations) indicate that only a very small fraction of the total amount of hard substrate in any part of the Study Area would be impacted by explosives. As a result, if attached macroalgae are in the immediate vicinity of an explosion, only a small number of them are likely to be impacted relative to their total population-level.

Sargassum distribution is difficult to predict (Gower & King, 2008; South Atlantic Fishery Management Council, 2002) and it may overlap with any of the locations where sea surface and underwater explosions are conducted. Only explosions occurring on or at shallow depth beneath the surface have the potential to impact floating macroalgae like *Sargassum*. In the Study Area, the relative coverage of *Sargassum* is very low ranging from less than 1 percent to 5 percent of the sea surface; see Section 3.3.2.3.5 (Diatoms and Brown Algae [Phylum Ochrophyta]) for details. *Sargassum* may be impacted by surface disturbances from shallow underwater or sea surface explosions, although *Sargassum* is resilient to natural conditions caused by wind, wave action, and severe weather that may break apart pieces of the mat or cause the mats to sink. In the unlikely situation that a *Sargassum* mat is broken by an explosion, the broken pieces may develop into new *Sargassum* mats because *Sargassum* reproduces by vegetative fragmentation (new plants develop from pieces of the parent plant) (South Atlantic Fishery Management Council, 1998). Impacts to *Sargassum* from explosions may potentially collapse the pneumatocysts (air sacs) that keep the mats floating at the surface. Evidence suggests that *Sargassum* will remain floating even when up to 80 percent of the pneumatocysts are removed (Zaitsev, 1971). So even if an explosion caused the collapse of most of a *Sargassum* mat’s pneumatocysts, it may not cause it to sink.

Ship shock trials employ the underwater detonation of large explosives but occur in designated areas well offshore, in waters too deep for bottom impacts (see Figure 2.3-1). As described above, Sargassum is fairly resilient to damage from explosions, and procedural mitigation for ship shock trials (Table 5.3-17) includes the avoidance of mats of floating vegetation. Accordingly, ship shock trials would not affect attached or floating vegetation and will not be analyzed further in this section.

The potential for seagrass to overlap with underwater and surface explosions is limited to the Key West Range Complex based on relevant mapping data, Figure 3.3-3 (Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute, 2012). Seagrasses may potentially be uprooted or damaged by sea surface or underwater explosions. They are much less resilient to disturbance relative to *Sargassum*; regrowth after uprooting can take up to 10 years (Dawes et al., 1997). Explosions may also temporarily increase the turbidity (sediment suspended in the water) of nearby waters, but the sediment would be expected to settle or disperse to pre-explosion conditions within a relatively short time (minutes to hours depending on sediment type and currents). Sustained high levels of turbidity may reduce the amount of light that reaches vegetation which it needs to survive. This scenario is not likely given the avoidance of explosions in almost all areas where seagrasses grow, i.e., estuaries, lagoons, and bays (Phillips & Meñez, 1988), and the use of best available georeferenced data to avoid submerged aquatic vegetation to the maximum extent practicable as described in Section 5.4.1.2 (Mitigation Area Assessment).

3.3.3.2.1.1 Impacts from Explosives Under Alternative 1

Impacts from Explosives Under Alternative 1 for Training Activities

Under Alternative 1, vegetation would be exposed to surface and underwater explosions and associated underwater impulsive sounds from high-explosive munitions (including bombs, missiles, torpedoes, medium- and large-caliber projectiles), mines, and demolition charges. Explosives would be used throughout the Study Area but typically in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems and in the Gulf Stream Open Ocean

Area. Explosives at or beneath the water surface would be used in all training range complexes. The only underwater explosions in the Key West Range Complex would result from use of 10- to 60-lb. shaped charges placed on the bottom by divers. Training activities involving the use of explosives are listed in Table B-1 of Appendix B (Activity Stressor Matrices), whereas the number and proposed locations of those activities are presented in Table 2.6-1 of Chapter 2 (Description of Proposed Action and Alternatives). A discussion of explosives and the number of detonations in each source class are provided in Section 3.0.3.3.2 (Explosive Stressors). The largest source class proposed for training under Alternative 1 is E12 (650 - 1,000 lb. net explosive weight), used during bombing exercises (air-to-surface) and sinking exercises.

Impacts to algae near the surface (phytoplankton and *Sargassum*) would be localized and temporary as discussed above and are unlikely to affect the abundance, distribution or productivity of vegetation. As discussed above, the depths, substrates, and relatively small areas of explosive footprints in comparison to vegetation distributions and total habitat areas in the Study Area indicate relatively little potential overlap between explosive footprints and the distribution of attached macroalgae or seagrasses. In addition, the Navy will not conduct explosive mine countermeasure and neutralization activities or explosive mine neutralization activities involving Navy divers within a 350-yd. radius of live hard bottom and submerged aquatic vegetation, except in designated locations, such as at Truman Harbor and Demolition Key, where these resources will be avoided to the maximum extent practicable (Table 5.4-1). Furthermore, the majority of explosions take place in soft bottom habitats as described in Section 3.5 (Habitats). As a result, explosions would have (if any) localized, temporary impacts consisting of damage to or the removal of individual plants and relatively small patches of vegetation. Vegetation is expected to regrow or recolonize the open patches created by explosives within a fairly short time (less than one year), resulting in no long-term effects on the productivity or distribution of attached macroalgae or seagrasses. Similarly, for *Sargassum* floating on the surface, explosions may shred individual plants in patches of *Sargassum*, but vegetative regrowth as well as the redistribution of *Sargassum* by currents would occur, resulting in only localized, temporary effects on distribution, cover and productivity. As described in Chapter 5 (Mitigation), activities that use explosives would not commence when concentrations of floating vegetation are observed prior to an activity, although *Sargassum* could be impacted where small patches are undetected or it drifts into the area after the activity starts. While the intent of the mitigation measure is to avoid impacting animals often associated with *Sargassum* mats, the mitigation provides the secondary effect of minimizing potential damage to *Sargassum* itself.

Based on Appendix F (Military Expended Material and Direct Strike Impact Analysis, Tables F-25 and F-33), it is estimated that over a 5-year period, a total of approximately 44.0 ac of bottom habitat would be impacted by explosives from training activities under Alternative 1. Eighty-nine percent of the area potentially impacted would be soft bottom habitat and thus have no direct impact on vegetation. The area of attached macroalgae habitats potentially impacted represents a very small fraction of the habitat within each training area and the Study Area as a whole, and much of that area would be avoided with the implementation of mitigation for seafloor resources or too deep for bottom impacts from surface explosions. The greatest potential for impacts on attached macroalgae would be on relatively small patches of hard or intermediate substrate that are unmapped or otherwise not included in the Protective Measures Assessment Protocol. Temporary disturbance of these habitats is not expected to affect the distribution, abundance, or productivity of vegetation.

As discussed in Section 5.3.3 (Explosive Stressors) and Section 5.4 (Mitigation Areas to be Implemented), the Navy will implement mitigation to avoid impacts from explosives on marine mammals and sea turtles (wherever activities occur) and on seafloor resources (within mitigation areas throughout the Study Area). Some biological resources can be indicators of potential marine mammal or sea turtle presence because marine mammals or sea turtles have been known to seek shelter in, feed on, or feed among them. For example, young sea turtles have been known to hide from predators and eat the algae associated with floating concentrations of *Sargassum*. For applicable explosive activities, 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 in concentrations, or the initial start of the activity will be halted until the mitigation zone is clear of the floating vegetation concentrations (there is no requirement to halt activities if vegetation floats into the mitigation zone after activities commence). One example of a mitigation designed for marine mammals and sea turtles that will consequently also help avoid potential impacts on vegetation is a requirement for the Navy to avoid commencing detonations within 600 yd. of an explosive sonobuoy if floating vegetation is observed. One example of a mitigation for seafloor resources is that the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom habitat, artificial reefs, and shipwrecks The mitigation for seafloor resources will consequently also help avoid potential impacts on vegetation that occurs in these areas.

The overlap of seagrass with this stressor does not include ESA-listed Johnson's seagrass (Figure 3.3-1), and the annual impact footprint of the planned underwater explosions on bottom habitats in the Key West Range Complex is estimated as only 0.20 ac under Alternative 1 for training activities (Appendix F [Military Expended Materials and Direct Strike Impact Analysis, Table F-22]). Explosive activities would not be conducted within 350 yd. of submerged aquatic vegetation except in designated areas which have been used historically, and where submerged aquatic vegetation would be avoided to the maximum extent practicable (Table 5.4-1). Thus only a very small area of seagrass could be impacted relative to the gross estimation of 130 NM^2 of seagrass in the range complex. Underwater explosions conducted for training activities are not expected to cause any risk to seagrass because: (1) the potential impact area of underwater explosions is very small relative to seagrass distribution, (2) the low number of charges reduces the potential for impacts, (3) disturbance (substrate disruption and turbidity) would be temporary, and 4) most importantly, the designation of submerged aquatic vegetation as a mitigation area, as well as the proximity of seagrass to shallow-water coral reefs, live hard bottom, and other mitigation areas (see Figures 3.4-8 and 3.4-9) protects large areas of seagrass from explosives training. Underwater and surface explosions are not anticipated to affect any of the general physical and biological features of critical habitat or areas that meet critical habitat criteria for Johnson's seagrass.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

Impacts from Explosives Under Alternative 1 for Testing Activities

Under Alternative 1, vegetation would be exposed to explosions at or beneath the water surface and the associated underwater impulsive sounds from high-explosive munitions (including bombs, missiles, torpedoes, and naval gun shells), mines, demolition charges, explosive sonobuoys, and ship shock trial charges. Explosives would be used throughout the Study Area, but most typically in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and in the Gulf Stream Open Ocean Area. Underwater explosions at or near the water surface could occur in all of the testing ranges and range complexes. Testing activities involving the use of explosives are listed in Table B-2 of Appendix B (Activity Stressor Matrices), whereas the number and proposed locations of those activities are presented in Table 2.6-2 and Table 2.6-3 of Chapter 2

(Description of Proposed Action and Alternatives). A discussion of explosives and the number of detonations in each source class are provided in Section 3.0.3.3.2 (Explosive Stressors). The largest source class proposed for annually occurring testing under Alternative 1 is E14 (1,741 to 3,625 lb. net explosive weight), used during mine warfare testing at Naval Surface Warfare Center, Panama City Division Testing Range. Larger source classes may be used in the Northeast U.S. Continental Shelf Large Marine Ecosystem, Southeast U.S. Continental Shelf Large Marine Ecosystem, and in the Gulf Stream Open Ocean Area during ship shock trials of three platforms in the Virginia Capes, Jacksonville, or Gulf of Mexico Range Complexes. Large ship shock trials could use charges up to source class E17 (14,500 - 58,000 lb. net explosive weight), while small ship shock trials could use charges up to source class E16 (7,250 - 14,500 lb. net explosive weight). Each full ship shock trial would use up to four of these charges in total (each one detonated about a week apart). In addition, use of explosives would occur in the Key West Range Complex during sonobuoy lot acceptance testing and at Naval Surface Warfare Center, Panama City Division for line charge testing.

Impacts to algae near the surface (phytoplankton and *Sargassum)* would be localized and temporary as discussed above for training activities and are unlikely to affect the abundance, distribution, or productivity of vegetation. As discussed above, the depths, substrates, and relatively small areas of explosive footprints in comparison to vegetation distributions and total habitat areas in the Study Area indicate relatively little overlap between explosive footprints and the distribution of attached macroalgae or seagrasses. As a result, explosions would have (if any) localized, temporary impacts consisting of damage to or the removal of individual plants and relatively small patches of vegetation. Vegetation is expected to regrow or recolonize the open patches created by explosives within a fairly short time (less than one year), resulting in no long-term effects on the productivity or distribution of attached macroalgae or seagrasses. Similarly, for *Sargassum* floating on the surface, explosions may shred individual plants in patches of *Sargassum*, but vegetative regrowth as well as the redistribution of *Sargassum* by currents would occur, resulting in only localized, temporary effects on distribution, cover, and productivity.

Based on Appendix F (Military Expended Material and Direct Strike Impact Analysis, Table F-34), it is estimated that over a 5-year period, a total of approximately 43.5 ac of bottom habitat would be impacted by the crater, expelled material, and explosive fragments associated with explosive testing activities under Alternative 1. Eighty-three percent of the area impacted would be offshore soft bottom habitat and thus have no effect on vegetation that is limited to hard substrate. The impacted area of hard and intermediate bottom habitat, as well as inshore soft bottom habitat represents a very small fraction of the habitat within each range and the Study Area as a whole. With the exception of line charge testing, which occurs in the surf zone at Naval Surface Warfare Center Panama City Division (Table 2.6-3; see activity description in Appendix A, A.3.2.7.3), most of the area affected would be too deep to support benthic algae. Line charge testing at Naval Surface Warfare Center Panama City Division occurs on sandy bottom habitats that do not support seagrass or algae. As a result, temporary disturbance of these habitats is not expected to affect the distribution, abundance, or productivity of vegetation.

As discussed in Section 5.3.3 (Explosive Stressors) and Section 5.4 (Mitigation Areas to be Implemented), the Navy will implement mitigation to avoid impacts from explosives on marine mammals and sea turtles (wherever activities occur) and on seafloor resources (within mitigation areas throughout the Study Area). Some biological resources can be indicators of potential marine mammal or sea turtle presence because marine mammals or sea turtles have been known to seek shelter in, feed on, or feed among them. For example, young sea turtles have been known to hide from predators and eat the algae associated with floating concentrations of *Sargassum*. For applicable explosive activities, 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 in concentrations, or the initial start of the activity will be halted until the mitigation zone is clear of the floating vegetation concentrations (there is no requirement to halt activities if vegetation floats into the mitigation zone after activities commence). One example of a mitigation designed for marine mammals and sea turtles that will consequently also help avoid potential impacts on vegetation is a requirement for the Navy to avoid commencing detonations within 600 yd. of an explosive sonobuoy if floating vegetation is observed. A prime example of mitigation for seafloor resources is that the Navy will not conduct explosive mine countermeasure and neutralization activities within 350 yd. of submerged aquatic vegetation, shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks except in designated locations, where these resources will be avoided to the maximum extent practicable (Table 5.4-1). The mitigation for seafloor resources will consequently also help avoid and minimize potential impacts on vegetation that occurs in these areas.

The overlap of seagrass with this stressor does not include ESA-listed Johnson's seagrass (Figure 3.3-1), although explosives would be used for testing activities in the Key West Range Complex under Alternative 1 (Table 3.0-28).

Pursuant to the ESA, the use of explosives during testing activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.2.1.2 Impacts from Explosives Under Alternative 2

Impacts from Explosives Under Alternative 2 for Training Activities

Impacts from explosives under Alternative 2 for training activities would be virtually identical (less than 1 percent difference in any location or overall) to those of Alternative 1 (Appendix F [Military Expended Materials and Direct Strike Impact Analysis, Table F-33]).

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

Impacts from Explosives Under Alternative 2 for Testing Activities

Impacts from explosives under Alternative 2 for testing activities would affect slightly greater areas than those of Alternative 1 (Appendix F [Military Expended Materials and Direct Strike Impact Analysis, Table F-32]). Based on proportional impacts as calculated in Appendix F (Military Expended Materials and Direct Strike Impact Analysis, Table F-34), it is estimated that over a 5-year period, approximately 50.5 ac of bottom habitat would be impacted by explosive fragments associated with testing activities under Alternative 2, versus 43.5 ac under Alternative 1. The difference is almost entirely due to the greater number of testing activities conducted on the Virginia Capes Range Complex and Naval Surface Warfare Center, Panama City Division Testing Range under Alternative 2; these activities would impact soft bottom habitat in relatively deep water and thus have no effect on benthic vegetation. Testing activities under Alternative 2 would result in the temporary disturbance of relatively small areas of hard and intermediate bottom habitat, but is not expected to affect the distribution, abundance, or productivity of vegetation.

The overlap of seagrass with this stressor does not include ESA-listed Johnson's seagrass (Figure 3.3-1), although explosives would be used for testing activities in designated portions of the Key West Range Complex under Alternative 2 (Table 3.0-27).

Pursuant to the ESA, the use of explosives during testing activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.2.1.3 Impacts from Explosives Under the No Action Alternative

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

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

3.3.3.3 Energy Stressors

Energy stressors include electromagnetic devices, lasers, and radar; their use and characteristics are described in Section 3.0.3.3.3 (Energy Stressors). Although plants are known to respond to magnetic field variations, effects on plant growth and development are not well understood (Maffei, 2014). The area of potential effects from electromagnetic devices or lasers is so small (limited to a few meters from source), and temporary, as to be discountable in terms of any effect on vegetation. Radar, which is high-frequency electromagnetic radiation, is not known to affect plants, and is rapidly absorbed and does not propagate more than a few feet under water. Energy stressors are not applicable to vegetation because of the lack of sensitivity of vegetation and will not be analyzed further in this section.

3.3.3.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts on vegetation of the various types of physical disturbance and strike stressors that may occur during Navy training and testing activities within the Study Area. For a list of Navy training and testing activities that involve these stressors refer to Tables B-1 and B-2, respectively, in Appendix B (Activity Stressor Matrices). The physical disturbance and strike stressors that may impact marine vegetation include (1) vessels, (2) in-water devices, (3) military expended materials, and (4) seafloor devices. Explosives are analyzed separately in Section 3.3.3.2 (Explosive Stressors).

The evaluation of the impacts from physical disturbance and strike stressors on vegetation focuses on proposed activities that may cause vegetation to be damaged by an object that is moving through the water (e.g., vessels and in-water devices), dropped into the water (e.g., military expended materials), deployed on the seafloor (e.g., mine shapes and anchors), or detonated in the water column (e.g., explosive fragments). Not all activities are proposed throughout the Study Area. Wherever appropriate, specific geographic areas of potential impact are identified.

Single-celled algae may overlap with physical disturbance or strike stressors, but the impact would be minimal relative to their total population-level and extremely high growth rates (Caceres et al., 2013). They also move with the surface tension of the water and tend to flow around a disturbance. Therefore, they will not be discussed further. Seagrasses and macroalgae on the seafloor and *Sargassum* on the sea surface are the only types of vegetation that occur in locations where physical disturbance or strike stressors may be more than minimal, in terms of impact. Therefore, only seagrasses, macroalgae, and *Sargassum* are analyzed further for potential impacts from physical disturbance or strike stressors.

There is no overlap of any of the physical disturbance and strike stressors with the known distribution of or designated critical habitat for Johnson's seagrass.

3.3.3.4.1 Impacts from Vessels and In-Water Devices

Vessels

Several different types of vessels (ships, submarines, boats, amphibious vehicles) are used during training and testing activities throughout the Study Area, as described in Section 3.0.3.3.4.1 (Vessels and In-Water Devices). Vessel movements occur intermittently, are variable in duration, ranging from a few hours to a few weeks, and are dispersed throughout the Study Area. Events involving large vessels are widely spread over offshore areas, while smaller vessels are more active in nearshore areas and inshore waters. The location and hours of Navy vessel usage for testing and training activities are most dependent upon the location of Navy ports, piers, and established at-sea testing and training ranges. With the exception of the establishment of the Undersea Warfare Training Range, the Navy's use of these areas has not appreciably changed in the last decade and are not expected to change in the foreseeable future.

The potential impacts from Navy vessels used during training and testing activities on vegetation are based on the vertical distribution of the vegetation. Vessels may impact vegetation by striking or disturbing vegetation on the sea surface or on the seafloor (the latter would only occur where amphibious vessels operate in nearshore to shore environments) (Spalding et al., 2003). Considering attached macroalgae does not typically persist along high energy beaches where amphibious landings occur, the only type of marine vegetation that may potentially be disturbed by vessels is *Sargassum*. *Sargassum* distribution is difficult to predict (Gower & King, 2008; South Atlantic Fishery Management Council, 2002) and it may overlap with many locations where vessels are used. In the Study Area, the relative coverage of *Sargassum* is very low, ranging from less than 1 percent to 5 percent of the sea surface; see Section 3.3.2.3.5 (Brown Algae [Phylum Phaeophyta]) for details. *Sargassum* may be impacted by vessels, although *Sargassum* is resilient to natural conditions caused by wind, wave action, and severe weather that may break apart pieces of the mat or cause the mats to sink. In the unlikely situation that a *Sargassum* mat is broken by a vessel or in-water device, the broken pieces may develop into new *Sargassum* mats because *Sargassum* reproduces by vegetative fragmentation (new plants develop from pieces of the parent plant) (South Atlantic Fishery Management Council, 1998). Impacts to *Sargassum* from vessels may potentially collapse the pneumatocysts that keep the mats floating at the surface. Evidence suggests that *Sargassum* will remain floating even when up to 80 percent of the pneumatocysts are removed (Zaitsev, 1971). Even if a vessel strike results in the collapse of most of a *Sargassum* mat's pneumatocysts, it may not cause it to sink.

Seagrasses are resilient to the lower levels of wave action that occur in sheltered estuarine shorelines, but are susceptible to vessel propeller scarring and substrate erosion by vessel wakes (Sargent et al., 1995; Stevenson et al., 1979), although vessel wakes appear to have only localized effects and are not considered a significant threat to seagrasses in general (Orth et al., 2010). Some tropical seagrasses can take up to 10 years to fully regrow and recover from propeller scars (Dawes et al., 1997). However, seagrasses do not typically grow along high energy beaches with shifting soft shore and bottom habitat, and thus do not overlap with amphibious combat vehicle activities based on relevant literature and resource maps (Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute, 2012; North Carolina Department of Environmental and Natural Resources, 2012). Within the Key West Range Complex, 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 (Table 5.4-1).

Additional mitigation for potential vessel-anchoring impacts is that the Navy will not conduct precision anchoring (except in designated anchorages) within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks (Table 5.4-1).

Seafloor macroalgae may be present in locations where these vessels occur, but the impacts would be minimal because vessels typically avoid direct contact with the bottom, and due to the resilience, distribution, and biomass of macroalgae. Because seafloor macroalgae in coastal areas are adapted to natural disturbances, such as storms and wave action that can exceed 10 m per second (Mach et al., 2007), macroalgae will quickly recover from vessel movements.

In-Water Devices

Several different types of in-water devices (i.e., towed devices, unmanned surface and underwater vehicles) are used during training and testing activities throughout the Study Area, as described in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.3.3.4.1 (Vessels and In-Water Devices). As described in Section 2.3.3 (Standard Operating Procedures), 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 (e.g., driftwood) and other objects (e.g., concentrations of floating vegetation), which have the potential to obstruct or damage the device. The standard operating procedure for towed in-water device safety could result in a secondary benefit to vegetation through a reduction in the potential for physical disturbance and strike of a towed in-water device.

The potential impacts from Navy in-water devices used during training and testing activities on marine vegetation are largely the same as those described above for vessels except as noted below. Vegetation on the seafloor such as seagrasses and macroalgae are unlikely to be impacted by in-water devices, which do not normally contact the bottom. Towed in-water devices include towed targets that are used during activities such as missile exercises and gun exercises. These devices are operated at low speeds either on the sea surface or below it. The analysis of in-water devices will focus on towed surface targets because of the potential for impacts on marine algae.

The only type of marine vegetation that may potentially be disturbed by in-water devices is *Sargassum*. Potential impacts would be as described for vessels and would be localized and temporary due to the ability of *Sargassum* mats to remain floating and regrow despite fragmentation from strikes.

3.3.3.4.1.1 Impacts from Vessels and In-Water Devices Under Alternative 1

Estimates of relative vessel and in-water device use by location for each alternative are provided in Tables 3.0-18, 3.0-19, 3.0-22, and 3.0-23 of Section 3.0.3.3.4.1 (Vessels and In-Water Devices). These estimates are based on the number of activities predicted for each alternative. While these estimates provide a prediction of use, actual Navy vessel and in-water device use depends upon military training and testing requirements, deployment schedules, annual budgets, and other unpredictable factors. Testing and training concentrations are most dependent upon locations of Navy shore installations and established training and testing ranges.

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

Vessels

Under Alternative 1, a variety of vessels would be used in the Study Area during up to 36, 208 annual training activities, as described in Section 3.0.3.3.4.1 (Vessels and In-Water Devices). Most activities would include either one or two vessels and may last from a few hours to two weeks. Roughly 85 percent of vessel activities would occur in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, while another 10 percent would occur in the inshore waters (Tables 3.0-18 and 3.0-19). Vessel use would occur elsewhere throughout the Study Area but at much lower frequency. A large proportion of the vessel activity in the inshore waters consists of small craft (less than 50 ft.) which often travel at high speed (greater than 10 knots) (Tables 3.0-19 and 3.0-20). The most heavily used areas would be in the Southeast and Northeast U.S. Continental Shelf Large Marine Ecosystems, as well as the Gulf Stream Open Ocean Area.

The wakes from large, high speed ferries have been implicated in shoreline erosion in at least one study (Parnell et al., 2007). More generally, however, the wakes associated with vessel traffic have not been identified as a cause of seagrass declines (Orth et al., 2010; Stevenson et al., 1979). Wakes from small Navy boats in the inshore waters are unlikely to have measurable impacts on vegetation because Navy vessels represents a small fraction of total maritime traffic and the wakes generated by small Navy boats which, for safety reasons are not operated at excessive speeds nearshore, are similar to wind waves that naturally occur.

Amphibious training events occur on sandy beaches such as at Marine Corps Base Camp Lejeune and at Naval Station Mayport, where seagrass and attached macroalgae are not expected because of the regular use and disturbance of the same areas by amphibious training exercises, as well as waves and currents that are too strong for vegetation to establish. The training ranges noted above for the majority of training activities intersect habitat for attached macroalgae and floating vegetation (*Sargassum*), suggesting potential impacts. However, the attached macroalgae may only be temporarily disturbed, and the floating *Sargassum* mats are resilient to disturbance as described in the previous introductory section on impacts.

Vessels used in training activities under Alternative 1 would not cause a detectable impact on *Sargassum* because: (1) the relative coverage of *Sargassum* in the Study Area is low, and (2) *Sargassum* is resilient and regrowth after exposure to vessels is expected to be rapid. Based on these factors, potential impacts to *Sargassum* from vessels are not expected to result in detectable changes to its growth, survival, or propagation, and are not expected to result in population-level impacts.

Because of the nature of vessel operation and intentional avoidance of bottom strikes, most shore and bottom habitats would not be exposed to vessel strikes but could be exposed to vessel disturbance by propeller wash. Groundings would be accidental and are rare. Amphibious vehicles are an exception, but only designated beaches that are naturally resilient to disturbance are used. Therefore, while vessels may affect shore and bottom habitats, adverse impacts are not likely. Seagrasses are vulnerable to localized damage from propellers where inshore vessel training overlaps the navigable portion of their habitat, though this stressor is considering very minor compared to other seagrass stressors (e.g., nutrient enrichment). The impact of vessel wakes on emergent wetlands is confined to high speed vessel movement along sheltered inland shorelines where a minimal impact is likely indistinguishable from that of other vessel traffic.

On the open ocean, strikes of vegetation would be limited to floating marine algae. Vessel movements may disperse or fragment algal mats. Because algal distribution is patchy, mats may re-form, and events would be on a small spatial scale.

The net impact of vessels on vegetation is expected to be negligible under Alternative 1, based on (1) relatively small areas of spatial coincidence between vessel disturbance zones and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of vessels during training activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

In-Water Devices

The use of in-water devices for training under Alternative 1 would occur during up to 17,238 annual activities. Activities would be concentrated in the Virginia Capes Range Complex with up to 7,316 activities annually, over half of the total for Alternative 1. The Jacksonville Range Complex would support up to 5,097 (20 percent of total) activities annually, whereas the Navy Cherry Point Range Complex would support up to 2,027 (12 percent of total) activities annually. Other parts of the Study Area would be used less frequently (Tables 3.0-22 and 3.0-23).

Under Alternative 1, the impacts from in-water devices during training activities would amount to minimal disturbances of algal mats and seaweeds. As described in Section 2.3.3.12 (Towed In-Water Device Safety), direct impacts would be minimized by the standard collision avoidance procedure for towed in-water devices, which includes searching the intended path of the device and avoiding concentrations floating vegetation. Seagrass bed damage is not likely but, if it occurs, the impacts would be minor, such as damage from short-term turbidity increases.

In-water devices used in training activities under Alternative 1 would not cause a detectable impact on *Sargassum* because: (1) the relative coverage of *Sargassum* in the Study Area is low, and (2) new growth may result from *Sargassum* exposure to in-water devices. Based on these factors, potential impacts to *Sargassum* from in-water devices are not expected to result in detectable changes to its growth, survival, or propagation, and are not expected to result in population-level impacts.

On the open ocean, strikes of vegetation would be limited to floating marine algae. Unmanned surface vessel or towed device movements may disperse or fragment algal mats. Because algal distribution is patchy, mats may re-form, and events would be on a small spatial scale.

Under Alternative 1, the impacts from in-water devices during training activities would be minimal disturbances of algal mats and seaweeds, primarily due to localized water motion, sediment disturbance and short-term turbidity increases. Seagrass bed damage is not likely to occur.

The net impact of in-water devices on vegetation is expected to be negligible under Alternative 1, based on (1) relatively small areas of spatial coincidence between disturbance zones from in-water devices and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of in-water device usage and local disturbances of the surface water and bottom habitat (the latter by bottom-crawling devices), with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of in-water devices during training activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

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

Vessels

Under Alternative 1, the Navy would use a variety of vessels in up to 7,564 annual testing activities in the Study Area, as described in Section 3.0.3.3.4.1 (Vessels and In-Water Devices). Most activities would include either one or two vessels and may last from a few hours to two weeks. Vessel testing activities would occur in all range complexes and testing ranges, and would be spread somewhat more evenly than training activities (Tables 3.0-18 and 3.0-19).

On the open ocean, vessel strikes of vegetation would be limited to floating marine algae, primarily *Sargassum* in the Study Area*.* Vessel movements may disperse or fragment algal mats*.* Because floating algae distributions are driven by winds and currents, mats that are broken up by vessel movements would tend to re-form, and events would be on a small spatial scale. Navy testing activities involving vessel movement would not impact the general health of marine algae.

Vessel disturbance and strike impacts on emergent marsh and seagrass vegetation due to testing activities would be essentially the same as described previously for training activities, with the exception that no amphibious vehicles are used in testing.

Testing activities may occur near seagrass beds (e.g., in the South Florida Ocean Measurement Facility) where vessels participating in testing events may cross sandy shallow habitat that could support the ESA-listed Johnson's seagrass. However, vessel movements at this location and elsewhere would not directly impact the bottom and the temporary increase in-water motion from vessels would be similar to natural wave action and unlikely to dislodge plants or increase turbidity to the point that photosynthesis may be impacted.

Vessels used in testing activities under Alternative 1 would not cause a detectable impact on *Sargassum* because: (1) the relative coverage of *Sargassum* in the Study Area is low, and (2) new growth may result from *Sargassum* exposure to vessels*.* Based on these factors, potential impacts to *Sargassum* from vessels are not expected to result in detectable changes to its growth, survival, or propagation, and are not expected to result in population-level impacts.

The net impact of vessels on vegetation is expected to be negligible under Alternative 1, based on (1) relatively small areas of spatial coincidence between vessel disturbance zones and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of in-vessels during testing activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

In-Water Devices

The use of in-water devices for testing under Alternative 1 would occur during up to 4,760 annual activities. Activities would be concentrated in the Virginia Capes Range Complex and Naval Undersea Warfare Center Newport, these two locations accounting for 48 percent of all activities (Table 3.0-22).

Under Alternative 1, the impacts from in-water devices during training activities would be minimal disturbances of algal mats and seaweeds. Seagrass bed damage is not likely but, if it occurs, the impacts would be minor, such as damage from short-term turbidity increases. In-water devices used in testing activities under Alternative 1 would not cause a detectable impact on *Sargassum* because: (1) the relative coverage of *Sargassum* in the Study Area is low, and (2) new growth may result from *Sargassum* exposure to in-water devices*.* Based on these factors, potential impacts to *Sargassum* from in-water devices are not expected to result in detectable changes to its growth, survival, or propagation, and are not expected to result in population-level impacts.

Under Alternative 1, the impacts from in-water devices during testing activities would be minimal disturbances of algal mats and seaweeds, primarily due to localized water motion, sediment disturbance and short-term turbidity increases. Seagrass bed damage is not likely to occur.

On the sea surface, towed and unmanned surface target strikes of vegetation would be limited to floating marine algal mats. Towed surface target and unmanned surface vehicle movements may disperse or injure algal mats. However, algal mats may re-form, and testing events would be on a small spatial scale. Therefore, Navy testing activities involving towed surface targets are not expected to impact the general health of marine algae.

The net impact of in-water devices on vegetation is expected to be negligible under Alternative 1, based on (1) relatively small areas of spatial coincidence between in-water device disturbance zones and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of in-water device movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of in-water devices during testing activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.4.1.2 Impacts from Vessels and In-Water Devices Under Alternative 2

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

Vessels

Vessel impacts from training under Alternative 2 would be as described previously for Alternative 1, but for minor differences in the number of activities by location. Compared to Alternative 1, under Alternative 2, training activities including vessels would be similarly distributed across ranges and facilities, but the number of activities over 5 years would increase by roughly 2 percent (Tables 3.0-18 and 3.0-19). Taking into account this small incremental increase in activities, the net impact on vegetation is still expected to be nearly identical to that of Alternative 1, and negligible based on (1) relatively small areas of spatial coincidence between vessel disturbance zones and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of vessels during training activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

In-Water Devices

In-water device impacts from training under Alternative 2 would be as described previously for Alternative 1, but for minor differences in the number of activities by location. Compared to Alternative 1, under Alternative 2, training activities including in-water devices would be similarly distributed across ranges and facilities, but the number of activities over 5 years would increase by roughly 6 percent (Table 3.0-22). Taking into account this small incremental increase in activities, the net impact on vegetation is still expected to be nearly identical to that of Alternative 1, and negligible based on (1) relatively small areas of spatial coincidence between vessel disturbance zones and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of in-water devices during training activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

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

Vessels

Vessel impacts from testing under Alternative 2 would be as described previously for Alternative 1, but for minor differences in the number of activities by location. Compared to Alternative 1, under Alternative 2, testing activities including vessels would be similarly distributed across ranges and facilities, but the number of activities over 5 years would increase by roughly 7 percent (Table 3.0-18 and 3.0-19). Taking into account this small incremental increase in activities, the net impact on vegetation is still expected to be nearly identical to that of Alternative 1, and negligible based on (1) relatively small areas of spatial coincidence between vessel disturbance zones and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of vessels during testing activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

In-Water Devices

In-water device impacts from testing under Alternative 2 would be as described previously for Alternative 1, but for minor differences in the number of activities by location. Compared to Alternative 1, under Alternative 2, training activities including in-water devices would be similarly distributed across ranges and facilities, but the number of activities over 5 years would increase by roughly 11 percent (Table 3.0-22). Taking into account this incremental increase in activities, the net impact on vegetation is still expected to be nearly identical to that of Alternative 1, and negligible based on (1) relatively small areas of spatial coincidence between vessel disturbance zones and the distribution of sensitive vegetation; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Pursuant to the ESA, the use of in-water devices during testing activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.4.1.3 Impacts from Vessels and In-Water Devices Under the No Action Alternative

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

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

3.3.3.4.2 Impacts from Aircraft and Aerial Targets

Aircraft and aerial target stressors are not applicable to vegetation and will not be analyzed further in this section.

3.3.3.4.3 Impacts from Military Expended Materials

This section analyzes the strike potential to vegetation of the following categories of military expended materials: (1) all sizes of non-explosive practice munitions, (2) expendable targets, and (3) expended materials other than munitions, such as sonobuoys, ship hulks, and miscellaneous accessories (e.g., canisters, endcaps, and pistons). Fragments from explosives are analyzed in Section 3.3.3.2.1 (Impacts from Explosives). See Appendix F (Military Expended Material and Direct Strike Impact Analysis) for more information on the types, locations, and quantities of military expended materials proposed to be used. The potential for impacts to marine vegetation from military expended materials would depend on the presence and amount of vegetation, and the size and number of military expended materials. Areas expected to have the greatest amount of expended materials are the Northeast U.S. Continental Shelf Large Marine Ecosystem, the Southeast U.S. Continental Shelf Large Marine Ecosystem, and the Gulf Stream Open Ocean Area (specifically within the Virginia Capes and Jacksonville Range Complexes).

Most types of military expended materials are deployed in the open ocean where they may impact *Sargassum*. Based on Appendix A (Navy Activity Descriptions), however, some expended materials including small- and medium-caliber projectiles and their associated casings, target fragments, marine markers (e.g., smoke floats), and countermeasures could be introduced into estuarine or nearshore areas where shallow water vegetation such as emergent wetlands, seagrass, and macroalgae may be located.

In the Study Area, the relative coverage of *Sargassum* is very low, ranging from less than 1 percent to 5 percent of the sea surface. Section 3.3.2.3.6.2 (*Sargassum*) contains additional detail. *Sargassum* may be impacted by military expended materials, although *Sargassum* is resilient to natural conditions caused by wind, wave action, and severe weather that may break apart pieces of the mat or cause the mats to sink. In the unlikely situation that a *Sargassum* mat is broken by military expended materials, the broken pieces may develop into new *Sargassum* mats because *Sargassum* reproduces by vegetative fragmentation (new plants develop from pieces of the parent plant) (South Atlantic Fishery Management Council, 1998). Impacts to *Sargassum* from military expended materials may potentially collapse the pneumatocysts that keep the mats floating at the surface. Evidence suggests that *Sargassum* will remain floating even when up to 80 percent of the pneumatocysts are removed (Zaitsev, 1971). Even if a military expended material's strike results in the collapse of most of a *Sargassum* mat's pneumatocysts, it may not cause it to sink. In addition, if enough military expended materials are deposited on *Sargassum*, the mats can potentially sink, but sinking also occurs as a natural part of the aging process of *Sargassum* (Schoener & Rowe, 1970).

Some types of attached macroalgae such as kelp only occur in a very small part of the Study Area in the Northeast U.S. Continental Shelf Large Marine Ecosystem, specifically in the Northeast Range Complexes, where a small fraction of the activities that involve military expended materials would be conducted. Most of these activities occurring in the Northeast Range Complexes would likely impact offshore soft bottom habitat that does not support kelp (Section 3.0.3.3.4.2, Military Expended Materials and Appendix F, Military Expended Material and Direct Strike Impact Analysis [Tables F-33 and F-34]; see also Figure 3.5-15). Other species of attached macroalgae may be found throughout the offshore range complexes on hard substrates in waters deeper than kelp but no deeper than about 200 m. Shallower offshore waters could be impacted by falling military expended materials, but the vegetation is fast growing and resilient to physical disturbance (Mach et al., 2007).

Most deposition of military expended materials occurs within the confines of established training and testing areas, although there is some deposition of expended materials in inshore waters (e.g., small-caliber shell casings and smoke floats in Chesapeake Bay and tributaries). The most heavily impacted areas are away from the coastline on the continental shelf and slope and the potential for impacts to vegetation other than *Sargassum* is low.

Military expended materials can potentially impact seagrass on the seafloor by disturbing, crushing, or shading which may interfere with photosynthesis. In the event that seagrass is not able to photosynthesize, its ability to produce energy is compromised. The intersection of seagrasses and the use of military expended materials is limited. The only range complex where military expended materials overlap with seagrasses is in the Key West Range Complex based on relevant mapping data, Figure 3.3-3 (Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute, 2012). Seagrass also occurs in relatively close proximity to testing ranges where expended materials would be generated, including the Naval Undersea Warfare Center Newport Testing Range and South Florida Ocean Measurement Facility (Figure 3.3-2 and Figure 3.3-3) and may be affected by materials that drift shoreward in these locations.

Seagrasses generally grow in waters that are sheltered from wave action such as estuaries, lagoons, and bays (Phillips & Meñez, 1988) landward of offshore training and testing ranges. However, seagrass does occur within some inshore training locations such as lower Chesapeake Bay (Figure 3.3-2). The impacts of military expended materials falling on seagrass beds are minimized by the flexible/fluid nature of seagrass blades and typical avoidance of extremely shallow water where vessel propulsion is impacted. The potential for detectable impacts on seagrasses from expended materials would be low given the small size or low density (e.g., small projectiles, decelerators/parachutes, endcaps, and pistons) of the majority of the materials that could be used in or drift into these areas from offshore. Larger, denser materials, such as non-explosive practice munitions and sonobuoys would be used farther offshore and are likely to sink rapidly where they land. Falling materials could cause bottom sediments to be suspended. Resuspension of the sediment could temporarily impact water quality and decrease light exposure but since it would be short-term (hours), the combined stressors from military expended materials would not likely impact the general health of seagrasses. Neither the ESA-listed species Johnson's seagrass, nor its critical habitat, overlap with the Study Area; however, an analysis of potential impacts is included due to its proximity to training and testing activity areas.

The following are descriptions of the types of military expended materials that can potentially impact *Sargassum*, attached macroalgae, and seagrass. *Sargassum* may potentially overlap with military expended materials anywhere in the Study Area. Attached macroalgae could be associated with hard bottom or intermediate bottom habitat (as described in Section 3.5, Habitats) anywhere in the Study Area in depths less than 200 m. The Key West Range Complex is the only location where these materials may overlap with seagrasses. Appendix F (Military Expended Materials and Direct Strike Impacts) present the number and location of activities that involve military expended materials that are proposed for use during training and testing activities by location and alternative.

Small-, Medium-, and Large-Caliber Projectiles. Small-, medium-, and large-caliber non-explosive practice munitions, or fragments of high-explosive projectiles expended during training and testing activities rapidly sink to the seafloor. The majority of these projectiles would be expended in the Northeast U.S. Continental Shelf Large Marine Ecosystem and Gulf Stream Open Ocean Area in the Virginia Capes Range Complex. Because of the small size of projectiles and their casings, damage to marine vegetation is unlikely. Large-caliber projectiles are primarily used offshore (at depths mostly greater than 85 ft.) while small- and medium-caliber projectiles may be expended in both offshore and coastal areas (at depths mostly less than 85 ft.). *Sargassum* and other marine algae and, to a lesser extent (because of their limited coastal distribution), seagrasses, could occur where these materials are expended.

Bombs, Missiles, and Rockets. Bombs, missiles, and rockets, or their fragments (if high-explosive) are expended offshore (at depths mostly greater than 85 ft.) during training and testing activities, and rapidly sink to the seafloor. *Sargassum* and other marine algae could occur where these materials are expended, but seagrass generally does not because of water depth limitations for activities that expend these materials.

Decelerators/Parachutes. Decelerators/Parachutes of varying sizes are used during training and testing activities. The types of activities that use decelerators/parachutes are listed in Appendix B (Activity Stressor Matrices), whereas the physical characteristics of these expended materials, where they are used, and the number of activities that would occur under each alternative are described in Section 3.0.3.3.5.2 (Decelerators/Parachutes). Seagrass may overlap with the use of small and medium-size decelerators/parachutes in the Gulf of Mexico Large Marine Ecosystem in the Key West Range Complex (Tables 3.0-32 and 3.0-34). *Sargassum* and other marine algae could occur in any of the locations where these materials are expended.

Targets. Many training and testing activities use targets. Targets that are struck by munitions could break into fragments, whereas targets such as Expendable Mobile Anti-Submarine Training Targets (Table 3.0-29) that are expended without being struck by munitions and broken into fragments are also considered. Expended targets and fragments vary in size and type, but most are expected to sink. Pieces of targets that are designed to float are recovered when possible. Target fragments would be spread out over large areas. *Sargassum* and other marine algae and seagrass could occur where these materials are expended.

Countermeasures. Defensive countermeasures (e.g., chaff and flares) are used to protect against incoming weapons (e.g., missiles). Chaff is made of aluminum-coated glass fibers and flares are pyrotechnic devices. Chaff, chaff canisters (pistons), and flare end caps are expended materials. Chaff and flares are dispensed from aircraft or fired from ships. Seagrass may overlap with chaff and flares expended in the Gulf of Mexico Large Marine Ecosystem in the Key West Range Complex. *Sargassum* and other marine algae could occur in any of the locations in which these materials are expended.

Vessel Hulks. Vessel hulks are large expended materials that result from sinking exercises in specific open ocean areas, outside the coastal portions of the range complexes. Since the potential impacts of vessel movements and munitions use are considered elsewhere, and the vessel hulks are sunk in the abyssal zone (too deep to support attached vegetation), potential impacts from vessel hulks as a physical disturbance and strike stressor will not be analyzed further in this section.

3.3.3.4.3.1 Impacts from Military Expended Materials Under Alternative 1

<u>**Impacts from Military Expended Materials Under Alternative 1 for Training Activities**</u>

As indicated in Appendix F (Military Expended Material and Direct Strike Impact Analysis), for training activities under Alternative 1, areas with the greatest number of expended materials are expected to be the Northeast and Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems, and the Gulf Stream Open Ocean Area. By far the greatest numbers of materials would be expended within the Virginia Capes, Jacksonville, and Navy Cherry Point Range Complexes, which would also have the largest areas of impact, along with the area used for sinking exercises (Table F-2).

Appendix F (Military Expended Material and Direct Strike Impact Analysis) provides the approximate footprints of military expended materials associated with training activities. The worst-case analysis of potential impacts (Tables F-27 and F-29) shows that even if impacts were to be concentrated within hard or intermediate bottom habitats, much less than 0.01 percent of any substrate type could be affected annually or over 5 years. For the analysis of potential impacts to vegetation, the proportional impact, assuming a uniform, non-overlapping distribution of activities and associated military expended materials within each training area, is considered a more realistic, though still unlikely, approximation of the acreage affected. This scenario does not account for areas of concentrated training, nor does it account for the clumping of military expended materials and explosives in a particular area and over a particular substrate type where a training or testing activity occurs. In reality, there are numerous factors presented in the previous section that reduce the impacts footprints on substrate types and associated vegetation reported in Appendix F. Based on proportional impacts as provided in Table F-31, it is estimated that annually, approximately 11.5 ac of hard bottom habitat, 10.5 ac of intermediate bottom habitat, 84.5 ac of soft bottom habitat, and 1.5 ac of unknown bottom habitat would be impacted by military expended materials associated with training activities under Alternative 1 (see Section 3.5, Habitats, for more detailed analysis). Macroalgae occurs primarily on hard substrate but may be present on all substrate types in waters less than approximately 200 m deep. The expended material footprint areas also include mapped seagrass in the Key West Range Complex in addition to some inshore training areas.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities within a specified distance of shallow-water coral reefs. The mitigation will consequently also help avoid potential impacts on vegetation that occurs in these areas.

Military expended materials used for training activities are not expected to pose a severe risk to marine algae or seagrass because: (1) there would be relatively small areas impacted relative to the area of vegetation; (2) most of the expended materials would fall offshore where only resilient macroalgae (either floating or attached to the seafloor) are present; (3) rapid recovery of macroalgae where impacts did occur either by colonizing the surface of expended materials or regrowth; and (4) mitigation will incidentally help avoid impacts to marine algae or seagrasses that are in proximity to shallow-water coral reefs. Based on the factors summarized here and described in Section 3.3.3.4.3 (Impacts from Military Expended Materials), potential impacts on marine algae and seagrass from military expended materials are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts or affect the distribution, abundance, or productivity of vegetation.

As shown in Figure 3.3-1, Johnson's seagrass occurs adjacent to, not within the Study Area, and the possibility that military expended materials would drift into and deposit within habitats supporting Johnson's seagrass is remote. Therefore, pursuant to the ESA, military expended materials associated with training activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

Impacts from Military Expended Materials Under Alternative 1 for Testing Activities

As indicated in Appendix F (Military Expended Material and Direct Strike Impact Analysis), for testing activities under Alternative 1, areas with the greatest number of expended materials are expected to be the Northeast and Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems, and the Gulf Stream Open Ocean Area. By far the greatest numbers of materials would be expended within the Jacksonville and Virginia Capes Range Complexes, which would also have the largest areas impacted (Tables F-14 and F-15).

Appendix F (Military Expended Material and Direct Strike Impact Analysis) provides the approximate footprints of military expended materials associated with testing activities. The worst-case analysis of potential impacts (Tables F-28 and F-30) shows that even if impacts were to be concentrated within hard or intermediate bottom habitats, much less than 0.01 percent of any substrate type could be affected annually or over 5 years. For the analysis of potential impacts to vegetation, the proportional impact, assuming a uniform, non-overlapping distribution of activities and associated military expended materials within each testing area, is considered a more realistic, though still unlikely, approximation of the acreage affected. This scenario does not account for areas of concentrated training, nor does it account for the clumping of military expended materials and explosives in a particular area and over a particular substrate type where a training or testing activity occurs. In reality, there are numerous factors presented in the previous section that reduce the impacts footprints on substrate types and associated vegetation reported in Appendix F. Based on proportional impacts as provided in Table F-32, it is estimated that annually, approximately 5.0 ac of hard bottom habitat, 5.0 ac of intermediate bottom habitat, 42.0 ac of soft bottom habitat, and 0.5 ac of unknown bottom habitat would be impacted by military expended materials associated with testing activities under Alternative 1 (see Section 3.5, Habitats for more detailed analysis). Macroalgae occurs primarily on hard substrate but may be present on all substrate types in waters less than approximately 200 m deep. The expended material footprint areas also include mapped seagrass in the Key West Range Complex in addition to some inshore training areas.

Depending on the size and type or composition of the expended materials and where they happen to strike vegetation, plants could be killed, fragmented, covered, buried, sunk, or redistributed. This type of disturbance would not likely differ from conditions created by waves or rough weather. If enough military expended materials land on algal mats, the mats can sink. Sinking occurs as a natural part of the aging process of marine algae (Schoener & Rowe, 1970). The likelihood is low that mats would accumulate enough material to cause sinking from military activities, as military expended materials are dispersed widely through an activity area. The few algal mats that would prematurely sink would not have an impact on populations. Strikes would have little impact, and would not likely result in the mortality of floating algal mats or other algae, although these strikes may injure the organisms that inhabit or are often associated with floating vegetation, including invertebrates, fish, sea turtles, marine mammals, and birds. See Sections 3.4 (Invertebrates), 3.6 (Fishes), 3.7 (Marine Mammals), 3.8 (Reptiles), and 3.9 (Birds and Bats) respectively.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities within a specified distance of shallow-water coral reefs. The mitigation will consequently also help avoid potential impacts on vegetation that occurs in these areas.

Military expended materials used for testing activities are not expected to pose a risk to marine algae or seagrass because: (1) there would be relatively small areas of spatial coincidence between military expended material footprints and the distribution of sensitive vegetation; (2) plants and patches of vegetation affected by expended materials are likely to regrow when torn or damaged, and to recolonize temporarily disturbed areas, within a relatively short time; and (3) seagrass overlap with areas where the stressor occurs is very limited (see Figure 3.3-3). Based on these factors, potential impacts on marine algae and seagrass from military expended materials are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts or affect the distribution, abundance, or productivity of vegetation.

Pursuant to the ESA, military expended materials produced by testing activities as described under Alternative 1 would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.4.3.2 Impacts from Military Expended Materials Under Alternative 2

Impacts from Military Expended Materials under Alternative 2 for Training Activities

Based on Appendix F (Military Expended Material and Direct Strike Impact Analysis, Tables F-27, F-29, F-31, and F-33) the footprints of military expended materials associated with training under Alternative 2 would be very similar those of Alternative 1 as described previously. For hard, intermediate, and unknown bottom habitats, there would be less than 0.5 acre difference over 5 years, whereas for soft bottom, the impact over 5 years would be 2.5 ac greater under Alternative 2. The slight increase in soft bottom impact would occur primarily within the Gulf of Mexico and Jacksonville Range Complexes and would be of no consequence to vegetation.

Activities under Alternative 2 would occur at a similar rate and frequency relative to Alternative 1, and physical disturbance and strike stressors experienced by individual plants or plant communities from military expended materials under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, military expended materials associated with training activities under Alternative 2 would have essentially the same impacts as Alternative 1 and, similar to Alternative 1, would not affect the distribution, abundance, or productivity of vegetation, or have population-level effects.

Pursuant to the ESA, military expended materials produced by training activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

Impacts from Military Expended Materials Under Alternative 2 for Testing Activities

Based on Appendix F (Military Expended Material and Direct Strike Impact Analysis, Tables F-28 and F-30) the footprints of military expended materials associated with testing under Alternative 2 would be very similar to those of Alternative 1. Based on proportional impacts as provided in Table F-32, over a 5-year period, testing under Alternative 2 would impact 0.5 ac more hard bottom, 1.0 ac more intermediate bottom, 5.5 ac more soft bottom, and less than 0.01 ac more of unknown bottom, with the largest differences occurring in the Virginia Capes, Northeast, and Jacksonville Range Complexes.

Activities under Alternative 2 would occur at a similar rate and frequency relative to Alternative 1, and physical disturbance and strike stressors experienced by individual plants or plant communities from military expended materials under Alternative 2 for testing activities are not expected to be meaningfully different than those described under Alternative 1. Therefore, military expended materials associated with testing activities under Alternative 2 would be essentially the same as those of

Alternative 1 and would not affect the distribution, abundance, or productivity of vegetation or have population-level effects.

Pursuant to the ESA, military expended materials produced by testing activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.4.3.3 Impacts from Military Expended Materials Under the No Action Alternative

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

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

3.3.3.4.4 Impacts from Seafloor Devices

For lists of the activities that use seafloor devices, see Appendix B (Activity Stressor Matrices); Section 3.0.3.3.4.3 (Seafloor Devices, Tables 3.0-35 and 3.0-36) provides locations and numbers of those activities. Seafloor devices include items that are placed on, dropped on, or moved along the seafloor such as anchors, anchor blocks, mine shapes, bottom-placed instruments, bottom-placed targets that are recovered (not expended), and robotic bottom-crawling unmanned underwater vehicles.

The use of anchors for precision anchoring training exercises involves the release of anchors in designated locations. These training activities typically occur within predetermined shallow water anchorage locations near ports with seafloors consisting of soft bottom substrate in areas that do not typically support seagrass or attached macroalgae. Mine shapes are deployed from various platforms and secured with up to a 2,700 lb. concrete mooring block. Mine shapes and anchors are normally deployed over soft sediments and are generally recovered within 7 to 30 days following the completion of the training or testing events. In the unlikely event of a drop on attached macroalgae, there would be a temporary impact while the anchor is present and thereafter, before regrowth. Mines shapes would likely not be deployed in the seagrass meadows because they are too shallow for typical deployments designed to simulate contact with a surface ship transiting deeper water. Mine shapes laid by fixed-wing aircraft in mine laying training exercises may not be recoverable, and are not recovered for several of the testing activities (Appendix A, Navy Activity Descriptions).

Bottom-placed instruments and targets would not be deployed in shallow and intertidal habitats that support seagrass or emergent marsh, or on deeper hard bottom habitats that support macroalgae. Therefore these devices are not expected to impact vegetation.

Crawlers are fully autonomous, battery-powered amphibious vehicles used for functions such as reconnaissance missions in territorial waters. These devices are used to classify and map underwater mines in shallow water areas. The crawler is capable of traveling 2 ft. per second along the seafloor and can avoid obstacles. The crawlers are equipped with various sonar sensors and communication equipment that enable these devices to locate and classify underwater objects and mines while rejecting miscellaneous clutter that would not pose a threat. Crawlers move over the surface of the seafloor could damage fragile vegetation as they move over the substrate. The crawlers may leave a trackline of depressed vegetation and sediments approximately 2 ft. wide (the width of the device) in their wake. However, since these crawlers operate in shallow water, any disturbed sediments would be redistributed by wave and tidal action shortly (days to weeks) following the disturbance. Disturbed vegetation should recover quickly from the temporary depression, as opposed to dredging or similar adverse impacts.

3.3.3.4.4.1 Impacts from Seafloor Devices Under Alternative 1

Impacts from Seafloor Devices Under Alternative 1 for Training Activities

As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), for training activities under Alternative 1, seafloor devices would be used in the Northeast and Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems, as well as the Gulf Stream Open Ocean Area—predominantly within the Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico Range Complexes; and in many inshore water locations but predominantly in lower Chesapeake Bay, James River & Tributaries, and York River (VA); Kings Bay (GA); and Truman Harbor and Demolition Key (FL) (Tables 3.0-35 and 3.0-36).

As detailed in Appendix F (Military Expended Material and Direct Strike Impact Analysis, Tables F-9, F-10, F-12), the overwhelming majority of bottom-placed devices used in training are recovered mine shapes.

Seafloor device operation, installation, or removal can potentially impact seagrass by physically removing vegetation (e.g., uprooting), crushing, temporarily increasing the turbidity (sediment suspended in the water) of waters nearby, or shading seagrass which may interfere with photosynthesis. If seagrass is not able to photosynthesize, its ability to produce energy is compromised. However, the intersection of seagrasses and the use of seafloor devices is limited. Bottom disturbance would be limited to the immediate area where the device is deployed. Fine sediments would be suspended in small quantities and be widely dispersed by waves and currents, settling back to the bottom in minutes to hours. No persistent or widespread effects on sedimentation or turbidity within or adjacent to the Study Area are anticipated. The only training use of seafloor devices that may potentially overlap with seagrass in the Study Area involves mine shapes used in the Gulf of Mexico Large Marine Ecosystem in the Naval Surface Warfare Center, Panama City Division Testing Range, St. Andrew Bay, Florida (Appendix F [Military Expended Material and Direct Strike Impact Analysis, Table F-12]).

Seagrasses and other vegetation found within relatively shallow waters of the Study Area are adapted to natural disturbance, and recover quickly from storms, as well as from wave and surge action. Bayside marine plant species, such as seagrasses, are found in areas where wave action is minimal. The use of seafloor devices may impact benthic habitats with vegetation, but the impacts would be limited in scale and temporary (not resulting in permanent loss of vegetation or damage to the habitat and its ability to support vegetation) for the following reasons:

- Impacts to vegetation would be limited to temporary coverage (7 to 30 days) until the mine shape is retrieved. Where vegetation is present, the most abundant and important species, including seagrasses and various types of macroalgae (Bedinger et al., 2013), propagate through subsurface rhizomes which function in nutrient uptake as well as in anchoring the plant. Mine shapes would cover a few square feet, affecting a small portion of an algal or seagrass bed. Following retrieval of the mine shape, relatively rapid regrowth of shoots from rhizomes would occur in the affected area.
- The impact of seafloor devices on attached macroalgae or seagrass is likely to be inconsequential because: (1) the area exposed to the stressor is extremely small relative to overall availability of habitat of each type, (2) most seafloor devices would be placed in soft bottom areas lacking attached macroalgae or seagrass habitat, to avoid snagging, and (3) rapid recovery of macroalgae or seagrass expected in the unlikely event of deployment on hard

substrate or seagrass habitat. Based on the factors summarized here and described in Section 3.3.3.4.4 (Impacts from Seafloor Devices), activities involving seafloor devices are not expected to yield any discernable impacts on the population of vegetation in the Study Area.

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

Impacts from Seafloor Devices Under Alternative 1 for Testing Activities

As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, seafloor device use for testing activities would occur with greatest frequency at the Naval Surface Warfare Center Panama City Testing Range, Naval Undersea Warfare Center Division Newport Testing Range, Virginia Capes Range Complexes, and South Florida Ocean Measurement Facility. Crawlers are used primarily on testing ranges (Appendix A, Navy Activity Descriptions, see A.3.2.4.6). Otherwise, as detailed in Appendix F (Military Expended Material and Direct Strike Impact Analysis, Table F-19), the overwhelming majority of bottom-placed devices used in testing activities are recovered mine shapes.

As for training activities, the use of seafloor devices may impact benthic habitats with vegetation, but the impacts would be limited in scale and temporary (not resulting in permanent loss of vegetation or damage to the habitat and its ability to support vegetation) for the same reasons as stated above for training. In addition, crawler movement over the surface of the seafloor could cause some limited damage to portions of plants through the crushing, abrasion, or snagging and tearing of thalli by the tracks of the crawler, but this would occur within a very small area (approximately 2 ft. wide) and is not expected to remove the holdfasts or rhizomes of plants, or to alter the substrate for longer than a single tidal cycle.

Seafloor devices installed in shallow water habitats under Alternative 1 testing activities would pose a negligible risk to vegetation because the effects would be generally limited to damage to portions of plants which would regrow within a fairly short time (weeks to months); and the underlying substrate conditions that influence the growth of vegetation would be briefly, if at all affected. Population- or community level impacts are unlikely because of the small, local impact areas, the frequency of testing activities, and the wider geographic distribution of seagrasses and macroalgae in and adjacent to range complexes and testing ranges.

The Navy will implement mitigation to avoid potential impacts from seafloor devices on seafloor resources in mitigation areas within the South Florida Ocean Measurement Facility, as discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources). For example, the Navy will use real-time geographic information system and global positioning system (along with remote sensing verification) during deployment, installation, and recovery of anchors and mine-like objects to avoid impacts on shallow-water coral reefs and live hard bottom. This mitigation will consequently help avoid potential impacts on vegetation that occurs in these areas.

Johnson’s seagrass and its critical habitat do not occur within the Study Area, and the possibility of indirect effects from sediment or expended materials generated elsewhere by testing use of seafloor devices under Alternative 1 is remote. Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 1 would have no effect on Johnson’s seagrass or its designated critical habitat.

3.3.3.4.4.2 Impacts from Seafloor Devices Under Alternative 2

Impacts from Seafloor Devices Under Alternative 2 for Training Activities

The use of seafloor devices for training activities under Alternative 2 would be identical, in terms of locations and number of activities, to those occurring under Alternative 1 (refer to Tables 3.0-35 and 3.0-36). As detailed in Appendix F (Military Expended Material and Direct Strike Impact Analysis, Tables F-9, F-10, F-12), the overwhelming majority of bottom-placed devices used in training activities are recovered mine shapes. As discussed under Alternative 1, these activities would have minor, temporary impacts under Alternative 2.

Johnson's seagrass and its critical habitat do not occur within the Study Area, and the possibility of indirect effects from sediment or expended materials generated elsewhere by training use of seafloor devices under Alternative 2 is remote. Pursuant to the ESA, the use of seafloor devices during training activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

Impacts from Seafloor Devices Under Alternative 2 for Testing Activities

The use of seafloor devices for testing activities under Alternative 2 would increase by approximately 7 percent over a 5-year period under Alternative 2 (refer to Table 3.0-35). The difference is due to the greater number of activities under Alternative 2 in the Virginia Capes Range Complex and at Naval Surface Warfare Center Panama City Testing Range. Neither location overlaps the distribution of the ESA-listed Johnson's seagrass, so there would be no difference between alternatives in the effect to this species.

As discussed under Alternative 1, these activities would have localized, temporary impacts. While there would be incrementally greater temporary impacts to vegetation under Alternative 2, the difference is considered minor and inconsequential.

Johnson's seagrass and its critical habitat do not occur within the Study Area, and the possibility of indirect effects from sediment or expended materials generated elsewhere by testing use of seafloor devices under Alternative 2 is remote. Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 2 would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.4.4.3 Impacts from Seafloor Devices Under the No Action Alternative

Impacts from Seafloor Devices Under the No Action Alternative for Training and Testing Activities

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

3.3.3.4.5 Impacts from Pile Driving

The effects of pile driving on vegetation would be limited to non-acoustic effects, i.e., substrate disturbance and the possible removal of relatively small amounts of vegetation during pile installation and removal. It is assumed that pile driving would occur in soft bottom habitats with unconsolidated sediments that would allow pile installation and removal at a fairly rapid pace (Section 3.0.3.3.1.3, Pile Driving). Such areas are not expected to support appreciable amounts of vegetation. However, both micro- and macroalgae colonize hard substrate quickly and would be removed when the pilings are removed (yet there would be no net loss of vegetation). Therefore, pile driving would have no impact to vegetation and will not be analyzed further in this section.

3.3.3.5 Entanglement Stressors

Entanglement stressors associated with Navy training and testing activities are described in Section 3.0.3.3.5 (Entanglement Stressors). Expended materials that have the potential to cause entanglement generally sink to the bottom or drift ashore, and thereby could come into contact with macroalgae or seagrasses, possibly abrading or breaking plants, but such effects would be isolated, very small in scale, and temporary as the vegetation would regrow. No effects on the productivity or distribution of vegetation are anticipated. The likelihood of entanglement stressors drifting ashore and damaging plants of the ESA-listed Johnson's seagrass is extremely remote. Pursuant to the ESA, potential entanglement stressors associated with training and testing activities would have no effect on Johnson's seagrass or its designated critical habitat.

3.3.3.6 Ingestion Stressors

Ingestion stressors associated with Navy training and testing activities are described in Section 3.0.3.3.6 (Ingestion Stressors). Ingestion stressors will not impact vegetation because plants use photosynthesis to obtain nutrients and energy and versus ingest foot matter; therefore, ingestion stressors are not discussed further in this section.

3.3.3.7 Secondary Stressors

This section analyzes potential impacts on marine vegetation exposed to stressors indirectly through impacts on habitat and prey availability.

3.3.3.7.1 Impacts on Habitat

Section 3.2 (Sediments and Water Quality) and Section 3.5 (Habitats) considered the impacts on marine sediments and water quality and abiotic habitats from explosives and explosion by-products, metals, chemicals other than explosives, and other materials (marine markers, flares, chaff, targets, and miscellaneous components of other materials). One example of a local impact on water quality could be an increase in cyanobacteria associated with munitions deposits in marine sediments. Cyanobacteria may proliferate when iron is introduced to the marine environment, and this proliferation can negatively affect adjacent habitats by releasing toxins, potentially creating hypoxic conditions. Introducing iron into the marine environment from munitions or infrastructure is not known to cause toxic red tide events; rather, these harmful events are more associated with natural causes (e.g., upwelling) and the effects of other human activities (e.g., agricultural runoff and other coastal pollution) (Hayes et al., 2007).

The analysis included in Section 3.2 (Sediments and Water Quality) determined that neither state nor federal standards or guidelines for sediments nor water quality would be violated by the No Action Alternative, Alternative 1, or Alternative 2. Therefore, because these standards and guidelines are structured to protect human health and the environment, and the proposed activities do not violate them, no indirect impacts are anticipated on vegetation from the No Action Alternative or by training and testing activities proposed by Alternative 1 or Alternative 2.

The analysis included in Section 3.5 (Habitats) determined that, for Alternative 1 and Alternative 2, impacts to abiotic substrates from military expended materials and explosives would amount to less than 0.04 percent of each substrate type, resulting in little impact on the ability of substrates to support biological communities (including attached vegetation). The No Action Alternative would eliminate these impacts. The indirect impact due to substrate disturbance would be relatively minor and inconsequential because of the small areas of the seafloor that would be affected and the temporary nature of the impact. Substrate would be disturbed, but not removed, and hence would be available for recolonization.

The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from explosives and physical disturbance and strike stressors on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). Mitigation will consequently help avoid potential secondary impacts on vegetation habitat within shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks.

3.3.3.7.2 Impacts on Prey Availability

Prey availability as a stressor is not applicable to vegetation and will not be analyzed further in this section. Impacts from the No Action Alternative or by training and testing activities proposed by Alternative 1 or Alternative 2 on prey availability are analyzed in the respective prey sections, such as invertebrates and fishes; see Sections 3.4 (Invertebrates) and 3.6 (Fishes) respectively.

Therefore, based on the information provided in these subsections, secondary stressors would not have an impact on vegetation.

3.3.4 Summary of Potential Impacts on Vegetation

Exposures to physical disturbance and strike stressors, and to explosives, occur primarily within the range complexes and testing ranges associated with the Study Area. The Navy identified and analyzed four physical disturbance or strike sub-stressors that have potential to impact vegetation: vessel strikes, in-water device strikes, military expended material strikes, and seafloor device strikes. Vessels and in-water devices may impact vegetation by striking or disturbing vegetation on the sea surface or seafloor. Marine algae could be temporarily disturbed if struck by moving vessels and in-water devices or by the propeller action of transiting vessels.

Vegetation may be temporarily disturbed if struck by military expended materials. This type of disturbance would not likely differ from conditions created by waves or rough weather. If enough military expended materials land on algal mats, the mats can sink. The likelihood is low that mats would accumulate enough material to cause sinking from military activities, as military expended materials are dispersed widely through an activity area. Seafloor device operation, installation, or removal could impact vegetation by physically removing portions of plants, crushing, temporarily increasing the turbidity (sediment suspended in the water) of waters nearby, or increasing shading which may interfere with photosynthesis.

The potential for an explosion to injure or destroy vegetation would depend on the amount of vegetation present, the number of munitions used, and their net explosive weight. In areas where vegetation and locations for explosions overlap, vegetation on the surface of the water, in the water column, or rooted in the seafloor may be impacted.

The net impact of physical disturbance and strike stressors and explosives on vegetation is expected to be negligible, based on (1) the implementation of mitigation; (2) the quick recovery of most vegetation types from holdfasts or rhizomes that are unlikely to be removed by the activities; and (3) the short-term nature of most activities and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Activities described in this EIS/OEIS that have potential impacts on vegetation are widely dispersed, affecting a very small portion of the vegetation in the Study Area at any given time. The stressors that have potential impacts on marine vegetation include physical disturbances or strikes (vessels and in-water devices, military expended materials, and seafloor devices), explosives, and secondary stressors, i.e., impacts on habitat. Unlike mobile organisms, vegetation cannot flee from stressors once exposed. Vegetation in the Study Area would experience localized, temporary impacts, from stressors having the potential to physically damage or disperse individual plants or patches of vegetation. Impacted areas are expected to recover in a short time through regrowth, reproduction, and passive dispersal by currents, without measurable population-level effects to distribution, abundance, or productivity.

3.3.4.1 Combined Impacts of All Stressors Under Alternative 1

Activities described in this EIS/OEIS under Alternative 1 that have potential impacts on marine vegetation are widely dispersed, and not all stressors would occur simultaneously in a given location. The stressors that have potential impacts on marine vegetation include physical disturbances or strikes (vessel and in-water devices, military expended materials, and seafloor devices) and explosives. Unlike mobile organisms, vegetation cannot flee from stressors once exposed. *Sargassum* is the type of marine vegetation most likely to be exposed to multiple stressors in combination because it occurs in large expanses and because more activities and the associated stressors occur at the surface than on the bottom. Discrete areas of the Study Area (mainly within offshore areas with depths mostly greater than 85 ft. in portions of range complexes and testing ranges) could experience higher levels of activity involving multiple stressors, which could result in a higher potential risk for impacts on *Sargassum* within those areas. The potential for seagrasses and attached macroalgae to be exposed to multiple stressors would be low because activities are not concentrated in areas with depths less than 85 ft. or in inshore waters where seagrasses are concentrated. Furthermore, relatively few activities involve explosions on the bottom. The combined impacts of all stressors would not be expected to impact marine vegetation populations because: (1) activities involving more than one stressor are generally short in duration, (2) such activities are dispersed throughout the Study Area, and (3) activities are generally scheduled where previous activities have occurred; e.g., underwater detonation areas in the Key West Range Complex that do not overlap mapped seagrass beds. The aggregate effect on marine vegetation would not observably differ from existing conditions.

3.3.4.2 Combined Impacts of All Stressors Under Alternative 2

Activities described in this EIS/OEIS under Alternative 2 that have potential impacts on marine vegetation are widely dispersed, and not all stressors would occur simultaneously in a given location. The stressors that have potential impacts on marine vegetation include physical disturbances or strikes (vessel and in-water devices, military expended materials, seafloor devices) and explosives. Combined Impacts of all stressors under Alternative 2 would similar to those under Alternative 1.

3.3.4.3 Combined Impacts of All Stressors Under the No Action Alternative

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

3.3.5 Endangered Species Act Determinations

Pursuant to the ESA, Navy training and testing activities would have no effect on Johnson's seagrass or its designated critical habitat because the Proposed Action does not have any elements with the potential to modify such habitat.

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

TABLE OF CONTENTS

List of Figures

List of Tables

3.4 Invertebrates

INVERTEBRATES SYNOPSIS

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

- Acoustics: Invertebrates could be exposed to noise from the proposed training and testing activities. However, available information indicates that invertebrate sound detection is primarily limited to low-frequency (less than 1 kilohertz [kHz]) particle motion and water movement that diminishes rapidly with distance from a sound source. The expected impact of noise on invertebrates is correspondingly diminished and mostly limited to offshore surface layers of the water column where only zooplankton, squid, and jellyfish are prevalent mostly at night when training and testing occur less frequently. Invertebrate populations are typically lower offshore, where most training and testing occurs, than inshore due to the scarcity of habitat structure and comparatively lower nutrient levels. Exceptions occur at nearshore and inshore locations where occasional pierside sonar, air gun, or pile driving actions occur near relatively resilient soft bottom or artificial substrate communities. Because the number of individuals affected would be small relative to population numbers, population-level impacts are unlikely.
- Explosives: Explosives produce pressure waves that can harm invertebrates in the vicinity of where they typically occur: mostly offshore surface waters where zooplankton, squid, and jellyfish are prevalent mostly at night when training and testing with explosives do not typically occur. Invertebrate populations are generally lower offshore than inshore due to the scarcity of habitat structure and comparatively lower nutrient levels. Exceptions occur where explosives are used on the bottom within nearshore or inshore waters on or near sensitive live hard bottom communities. Soft bottom communities are resilient to occasional disturbances. Due to the relatively small number of individuals affected, population-level impacts are unlikely.
- Energy: The proposed activities would produce electromagnetic energy that briefly affects a very limited area of water, based on the relatively weak magnetic fields and mobile nature of the stressors. Whereas some invertebrate species can detect magnetic fields, the effect has only been documented at much higher field strength than what the proposed activities generate. High-energy lasers can damage invertebrates. However, the effects are limited to surface waters where relatively few invertebrates species occur (e.g., zooplankton, squid, jellyfish), mostly at night when actions do not typically occur, and only when the target is missed. Due to the relatively small number of individuals that may be affected, population-level impacts are unlikely.
- Physical Disturbance and Strike: Invertebrates could experience physical disturbance and strike impacts from vessels and in-water devices, military expended materials, seafloor devices, and pile driving. Most risk occurs offshore (where invertebrates are less abundant) and near the surface where relatively few invertebrates occur during the day when actions are typically occurring. The majority of expended materials are used in areas far from nearshore and inshore bottom areas where invertebrates are the most abundant. Exceptions occur for actions taking place within inshore and nearshore waters over primarily soft bottom communities, such as related to vessel transits, inshore and nearshore vessel training, nearshore explosive ordnance disposal training,

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INVERTEBRATES SYNOPSIS

- Physical Disturbance and Strike (continued): operation of bottom-crawling seafloor devices, and pile driving. Invertebrate communities in affected soft bottom areas are naturally resilient to occasional disturbances. Accordingly, population-level impacts are unlikely.
- Entanglement: Invertebrates could be entangled by various expended materials (wires, cables, decelerators/parachutes, biodegradable polymer). Most entanglement risk occurs in offshore areas where invertebrates are relatively less abundant. The risk of entangling invertebrates is minimized by the typically linear nature of the expended structures (e.g., wires, cables), although decelerators/parachutes have mesh that could pose a risk to those invertebrates that are large and slow enough to be entangled (e.g., jellyfish). Deep-water coral could also be entangled by drifting decelerators/parachutes, but co-occurrence is highly unlikely given the extremely sparse coverage of corals in the deep ocean. Accordingly, population-level impacts are unlikely.
- Ingestion: Small expended materials and material fragments pose an ingestion risk to some invertebrates. However, most military expended materials are too large to be ingested, and many invertebrate species are unlikely to consume an item that does not visually or chemically resemble its natural food. Exceptions occur for materials fragmented by explosive charges or weathering, which could be ingested by filter- or deposit-feeding invertebrates. Ingestion of such materials would likely occur infrequently, and only invertebrates located very close to the fragmented materials would potentially be affected. Furthermore, the vast majority of human-deposited ingestible materials in the ocean originate from non-military sources. Accordingly, population-level impacts are unlikely.
- Secondary: Secondary impacts on invertebrates are possible via changes to habitats (sediment or water) and to prey availability due to explosives, explosives byproducts, unexploded munitions, metals, and toxic expended material components. Other than bottom-placed explosives, the impacts are mostly in offshore waters where invertebrates are less abundant. The impacts of occasional bottom-placed explosives are mostly limited to nearshore soft bottom habitats that recover quickly from disturbance. Following detonation, concentrations of explosive byproducts are rapidly diluted to levels that are not considered toxic to marine invertebrates. Furthermore, most explosive byproducts are common seawater constituents. Contamination leaching from unexploded munitions is likely inconsequential because the material has low solubility in seawater and is slowly delivered to the water column. Heavy metals and chemicals such as unspent propellants can reach harmful levels around stationary range targets but are not likely in open waters where proposed action targets are typically mobile or temporarily stationary. Accordingly, overall impacts of secondary stressors on widespread invertebrate populations are not likely. Impacts due to decreased availability of prey items (fish and other invertebrates) would likely be undetectable.

3.4.1 Introduction

This chapter provides the analysis of potential impacts on marine invertebrates found in the Atlantic Fleet Training and Testing (AFTT) Study Area (Study Area). This section provides an introduction to the species that occur in the Study Area.

The affected environment provides the context for evaluating the effects of the Navy training and testing activities on invertebrates. Because invertebrates occur in all habitats, activities that interact with the water column or the bottom could potentially impact many species and individuals, including microscopic zooplankton (e.g., invertebrate larvae, copepods, protozoans) that drift with currents, larger invertebrates living in the water column (e.g., jellyfish, shrimp, squid), and benthic invertebrates that live on or in the seafloor (e.g., clams, corals, crabs, worms). Because many benthic animals have limited mobility compared to pelagic species, activities that contact the bottom generally have a greater potential for impact. Activities that occur in the water column generally have a lesser potential for impact due to dilution and dispersion of some stressors (e.g., chemical contaminants), potential drifting of small invertebrates out of an impact area, and the relatively greater mobility of open water invertebrates large enough to actively leave an impact area.

The following subsections provide brief introductions to the major taxonomic groups and Endangered Species Act (ESA)-listed species of marine invertebrates that occur in the Study Area. The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) maintains a website that provides additional information on the biology, life history, species distribution (including maps), and conservation of invertebrates.

3.4.2 Affected Environment

Three subsections are included in this section. General background information is given in Section 3.4.2.1 (General Background), which provides summaries of habitat use, movement and behavior, sound sensing and production, and threats that affect or have the potential to affect natural communities of marine invertebrates within the Study Area. Species listed under the ESA are described in Section 3.4.2.2 (Endangered Species Act-Listed Species). General types of marine invertebrates that are not listed under the ESA are reviewed in Section 3.4.2.3 (Species Not Listed Under the Endangered Species Act).

3.4.2.1 General Background

Invertebrates, which are animals without backbones, are the most abundant life form on Earth, with marine invertebrates representing a large, diverse group with approximately 367,000 species described worldwide to date (World Register of Marine Species Editorial Board, 2015). However, it is estimated that most existing species have not yet been described (Mora et al., 2011). The total number of invertebrate species that occur in the Study Area is unknown, but is likely to be many thousands. The results of a research effort to estimate the number of marine invertebrate species in various areas identified over 3,000 species in the Northeast United States (U.S.) Continental Shelf Large Marine Ecosystem and over 10,000 species in the Gulf of Mexico (Fautin et al., 2010). Invertebrate species vary in their use of abiotic habitats and some populations are threatened by human activities and other natural changes, especially endangered species.

Marine invertebrates are important ecologically and economically, providing an important source of food, essential ecosystem services (coastal protection, nutrient recycling, food for other animals, habitat formation), and income from tourism and commercial fisheries (Spalding et al., 2001). The health and abundance of marine invertebrates are vital to the marine ecosystem and the sustainability of the world's fisheries (Pauly et al., 2002). Economically important invertebrate groups that are fished, commercially and recreationally, for food in the United States include crustaceans (e.g., shrimps, lobsters, and crabs), bivalves (e.g., scallops, clams, and oysters), echinoderms (e.g., sea urchins and sea cucumbers), and cephalopods (e.g., squids and octopuses) (Chuenpagdee et al., 2003; Food and Agriculture Organization of the United Nations, 2005; Pauly et al., 2002). Marine invertebrates or the structures they form (e.g., shells and coral colonies) are harvested for many purposes, including jewelry, curios, and the aquarium trade. In addition, some marine invertebrates are sources of chemical compounds with potential medical applications. Natural products have been isolated from a variety of marine invertebrates and have shown a wide range of therapeutic properties, including anti-microbial, antioxidant, anti-hypertensive, anticoagulant, anticancer, anti-inflammatory, wound healing and immune modulation, and other medicinal effects (De Zoysa, 2012).

3.4.2.1.1 Habitat Use

Marine invertebrates live in all of the world's oceans, from warm shallow waters to cold deep waters. They inhabit the bottom and all depths of the water column in all the large marine ecosystems (West Greenland, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea) and open ocean areas (Labrador Current, Gulf Stream, and North Atlantic Gyre) in the Study Area (Brusca & Brusca, 2003). Many species that occur in the water column are either microscopic or not easily observed with the unaided eye (e.g., protozoans, copepods, and the larvae of larger invertebrate species). Many invertebrates migrate to deeper waters during the day, presumably to decrease predation risk. However, some invertebrates, such as some jellyfish and squid species, may occur in various portions of the water column, including near the surface, at any time of day. In addition, under certain oceanographic conditions, other types of invertebrates (e.g., pelagic crabs and by-the-wind sailors [*Velella velella*]) may occur near the surface during the day. The Study Area extends from the bottom up to the mean high tide line (often termed mean high water in literature). The description of habitat use in this section pertains to common marine invertebrates found in the different habitats. This section also identifies marine invertebrates that form persistent habitats, which are considered to be structures that do not quickly disintegrate or become incorporated into soft or intermediate substrate after the death of the organism. The principal habitat-forming invertebrates are corals and shellfish species (e.g., oysters, mussels). In a strict sense, individual invertebrates with hard shells (e.g., molluscs), outer skeletons (e.g., crabs), tubes (e.g., annelid worms), or cavities (e.g., sponges) also may be habitat-forming, providing attachment surfaces or living spaces for other organisms. The abiotic (nonliving) components of all habitat types are addressed in Section 3.5 (Habitats), and marine vegetation components are discussed in Section 3.3 (Vegetation).

Marine invertebrate distribution in the Study Area is influenced by habitat (e.g., abiotic substrate, topography, biogenic [formed by living organisms] features), ocean currents, and physical and water chemistry factors such as temperature, salinity, and nutrient content (Levinton, 2009). Distribution is also influenced by distance from the equator (latitude) and distance from shore. In general, the number of marine invertebrate species (species richness) increases toward the equator (Cheung et al., 2005; Macpherson, 2002). Species richness and overall abundance are typically greater in coastal water habitats compared to the open ocean due to the increased availability of food and protection that coastal habitats provide (Levinton, 2009).

The diversity and abundance of Arthropoda (e.g., crabs, lobsters, and barnacles) and Mollusca (e.g., snails, clams, scallops, and squid) are highest on the bottom over the continental shelf due to high productivity and availability of complex habitats relative to typical soft bottom habitat of the deep ocean (Karleskint et al., 2006). Organisms occurring in the bathyal and abyssal zones of the ocean are generally small and have sparse populations (Nybakken, 1993). The deep ocean has a limited food supply for sedentary deposit or filter feeders. The only areas of the deep ocean known to be densely populated are hydrothermal vents and cold seeps (refer to Section 3.5, Habitats, for additional information on these features).

Sandy coastal shores are dominated by species that are adapted to living in shifting substrates, many of which are highly mobile and can burrow. Common invertebrates in these habitats include mole crabs (*Emerita talpoida*), coquina clams (*Donax variabilis*), and a variety of isopods, amphipods, snails, and worms (South Carolina Department of Natural Resources & National Oceanic and Atmospheric Administration, 1996b; Tewfik et al., 2016). Inland soft shores consist of mud flats and sand flats that occur in areas sheltered from strong currents and waves. Soft shore habitats may support a wide variety of invertebrate species including amphipods, decapods, snails, bivalves, worms, and echinoderms (Dineen, 2010; South Carolina Department of Natural Resources & National Oceanic and Atmospheric Administration, 1996a). Habitat-forming invertebrates such as eastern oyster (*Crassostrea virginica*) may occur in coastal flats.

Intermediate (e.g., cobble, gravel) and rocky shores provide habitat for a variety of marine invertebrates, such as sea anemones, barnacles, chitons, limpets, mussels, urchins, sea stars, sponges, tunicates, and various worms. Rocky intertidal invertebrates may be attached or free living/mobile, and use various feeding strategies (filter-feeders, herbivores, carnivores, scavengers). Many invertebrates occurring in rocky intertidal zones are preyed upon by fish, birds, and other invertebrates. This particular habitat does not coincide with any of the proposed actions and will therefore not be discussed further. However, hard artificial structures such as pier pilings and seawalls can have a similar community of invertebrates that are in close proximity to some of the proposed actions.

Vegetated habitats, such as kelp forests in nearshore subtidal habitats, seagrasses found in sheltered inshore or nearshore waters, and floating *Sargassum* aggregations in nearshore and offshore locations, support a wide variety of marine invertebrate species. Kelp (primarily *Laminaria* species) occurs in the North Atlantic portion of the Study Area, with the southern limit considered to be Long Island Sound (Steimle & Zetlin, 2000). A large number of invertebrate species may be associated with this vegetated habitat. For example, kelp habitats in the Gulf of Maine support a variety of amphipods, isopods, shrimps, crabs, lobsters, sea stars, hydroids, and tunicates (Woodward, 2012). Seagrasses may support numerous worms, sea cucumbers, crabs, molluscs, and anemones, among other taxa. Seagrasses provide a rich source of food for many invertebrates, primarily in the form of epiphytes (non-parasitic plants that grow on other plants) (Florida Museum of Natural History, 2016). Approximately 145 invertebrate species representing a wide range of taxa have been identified in association with floating *Sargassum* algae (Trott et al., 2011). Ten of these species are thought to be endemic to *Sargassum* habitats (South Atlantic Fishery Management Council, 2002).

Rocky reefs and other rocky habitats may occur in subtidal zones. Invertebrate species composition associated with rocky subtidal habitats may be influenced by depth, size, and structural complexity of the habitat. Hundreds of invertebrate species may occur in rocky habitats, which provide attachment sites for sessile (attached to the bottom) species such as barnacles, bryozoans, limpets, sea anemones, sea fans, sponges, and tunicates, among others. Other invertebrates move about or shelter in crevices, including crustaceans (e.g., crabs, lobsters), echinoderms (e.g., brittle stars, sea cucumbers, sea urchins, sea stars), and molluscs (e.g., snails, nudibranchs, sea hares, octopus).

Shallow-water coral reefs are formed by individual corals with symbiotic, structure-forming algae that require both light and a mean annual water temperature greater than about 64 degrees Fahrenheit (National Ocean Service, 2016a; Nybakken, 1993). Shallow-water corals occur in the euphotic zone, which is the upper layer of the ocean where light levels are sufficient to support photosynthesis in the symbiotic algae. Shallow-water coral species typically occur in water depths less than 30 meters (m). Shallow-water coral reefs occur on hard substrate in southern and southeastern portions of the Study Area, including the southern part of the Gulf of Mexico Large Marine Ecosystem, throughout the Caribbean Sea Large Marine Ecosystem, and in the southern part of the Southeast U.S. Continental Shelf Large Marine Ecosystem. In addition to the presence of many individual corals, coral reefs also support hundreds of other marine invertebrate species, including representatives of most taxa. Researchers compiled historical and recent information on the amount of hard reef structure covered by living corals at 90 reef locations in the wider Caribbean Sea (primarily shallow reefs in water depths of 1 to 20 m) (Jackson et al., 2014). Average coral coverage on the hard reef structure is estimated to be approximately 14 to 17 percent, down from approximately 35 percent during the period of 1970 to 1983. Coverage declined in 75 percent of surveyed locations, including the Upper Florida Keys and Dry Tortugas areas. Shallow-water coral reefs may contain ESA-listed coral species, and changes in overall coral coverage provides a context for subsequent discussion of these species Section 3.4.2.2 (Endangered Species Act-Listed Species).

Deep-water corals occur in water depths where there is low or no light penetration and therefore typically lack symbiotic algae. As such, deep-water corals do not typically form biogenic reefs, but rather form mounds of intermediate (cobble-sized) substrate termed “lithoherms” over hard bottom areas (Lumsden et al., 2007). Differences in water clarity and the resulting light penetration at various locations affect the specific depth at which deep-water corals are found. However, in general, deep-water species are considered to occur at depths below 50 m (National Ocean and Atmospheric Administration, 2016; National Oceanic and Atmospheric Administration & National Marine Fisheries Service, 2008). To build their supporting structures, stony corals require calcium carbonate in the form of aragonite or calcite, which they obtain from seawater where carbonate is in solution. Combinations of temperature and pressure result in a boundary, often called the saturation depth, below which aragonite and calcite tend to dissolve. Therefore, corals (and other invertebrates) occurring below this boundary have difficulty forming persistent structures that contain calcium carbonate, and the aragonite saturation boundary imposes a depth limit for stony coral occurrence. The depth of the saturation boundary varies in different locations, ranging from about 200 to 3,000 m. Accordingly, deep-water corals are found in the depth range of about 50 to 3,000 m (Bryan & Metaxas, 2007; Lumsden et al., 2007; Quattrini et al., 2015; Tittensor et al., 2009), which confines them to the Coastal Large Marine Ecosystems and seamounts. The primary taxa of deep-water corals include hexacorals (stony corals, black corals, and gold corals), octocorals (e.g., true soft corals, gorgonians, and sea pens), and hydrocorals (e.g., lace corals) (Hourigan et al., 2017a). Of the approximately 600 coral species that occur at depths below 50 m, about 20 are considered structure-forming (Hourigan et al., 2017a). Stony corals such as ivory tree coral (*Oculina varicosa*), *Lophelia pertusa*, and *Enallopsammia profunda* provide three-dimensional structure that may be utilized by other marine species. However, taxa such as black corals, gorgonians, and sea pens may also provide habitat for other marine species, particularly when they occur in dense aggregations. With the exception of sea pens, which occur in soft substrate, deep-water corals generally attach to hard or intermediate substrates exposed to strong currents that provide a steady supply of plankton (algae and small animals that drift in the water) to feed on, and that reduce sedimentation that would inhibit colonization and growth of these slow-growing species (Bryan &

Metaxas, 2007; Tsao & Morgan, 2005). Spatial information on the hard and intermediate substrate habitats typically occupied by deep-water structure-forming corals is provided in Section 3.5 (Habitats).

A transition zone of reduced light levels, called the mesophotic zone, occurs between the water depths typically associated with shallow-water and deep-water corals. Mesophotic coral communities are composed of stony corals, soft corals, and other structure-forming organisms such as algae and sponges. Some corals with symbiotic, photosynthetic algae occur in the mesophotic zone, although the algae often undergo photosynthesis at reduced rates and the corals, therefore, rely more heavily on planktonic food capture compared to individuals that occur in the euphotic zone. Black corals and octocorals, which do not contain photosynthetic algae, are also characteristic of mesophotic communities. The depth range of the mesophotic zone depends on water clarity, but it is generally considered to extend from 30 m to about 100 to 150 m. Mesophotic communities may occur as deeper extensions of shallow-water reefs or other hard bottom communities (typically in the coastal zone), or they may occur in offshore locations with no connection to shallow-water communities. Mesophotic reefs are usually not detectable on satellite images, which increases the difficulty of identifying and mapping these features. The highest concentrations of stony corals typically occur on persistent, high-relief bottom features that represent a small subset of the hard and, to a lesser extent, intermediate substrates of the Study Area. Spatial information on the hard and intermediate habitats typically occupied by mesophotic structure-forming corals is provided in Section 3.5 (Habitats). Pulley Ridge, which is located within the Key West Range Complex about 100 miles west of the Dry Tortugas, is an example of a mesophotic coral ecosystem occurring in the Study Area. The ridge is about 5 kilometers (km) wide and rises less than 10 m above the surrounding seafloor, with a depth range of about 60 to 90 m (Baker et al., 2016; Halley et al., 2005). Corals containing photosynthetic algae occur in water depths to 70 m. Surveys conducted at Pulley Ridge using remotely operated vehicles found that stony corals covered only about 1.3 percent of observed substrate overall (Reed et al., 2015).

Chemosynthetic communities may support a relatively high biomass of marine invertebrates. Instead of using photosynthesis driven by sunlight, chemosynthetic organisms derive energy from chemicals originating from the earth’s crust. The primary types of habitats supporting chemosynthetic communities are hydrothermal vents and cold seeps. Hydrothermal vents form when seawater permeates downward through the earth’s crust and upper mantle, becomes superheated, and removes minerals and chemicals from the crust. The heated fluid may then rise through fissures in the crust and reach cold ocean water at the seafloor, where metals and other minerals precipitate out of solution to form mounds or chimneys. Communities of microbes, such as bacteria, may colonize these structures and use chemicals occurring in the fluid (primarily hydrogen sulfide or methane) to make energy. The microbes may then become the base of a food web that contains invertebrates such as crabs, clams, mussels, worms, snails, and shrimp (Ross et al., 2012; Woods Hole Oceanographic Institution, 2015). Cold seeps are similar to hydrothermal vents, but the fluid exiting the crust is cooler, typically moves at a slower rate, and may spread over a larger area. Methane hydrates (ice-like structures that contain methane) are associated with some chemosynthetic communities. Cold seeps are generally associated with hard substrate on offshore shelf breaks, submarine canyons, seamounts, and along the Mid-Atlantic Ridge; refer to Section 3.5 (Habitats) for spatial information on the habitats typically occupied by chemosynthetic communities. Of these features, only seamounts and the Mid-Atlantic Ridge occur in the abyssal zone portion of the Study Area, outside of the Coastal Large Marine Ecosystems.

Although chemosynthetic communities have not been well studied off the U.S. Atlantic coast in the past, the number of known and potential sites has increased substantially due to recent investigations. Whereas hydrothermal vents are primarily located in geologically active areas (e.g., seamounts, Mid-Atlantic Ridge), cold seeps have been documented off Massachusetts, Maryland, Virginia, and South Carolina (National Oceanic and Atmospheric Administration, 2013; National Oceanic and Atmospheric Administration Ocean Explorer, 2010, 2012, 2013). Over 500 seeps have been identified at upper portions of the continental slope between Cape Hatteras, North Carolina and Georges Bank, Maine, many of which are associated with submarine canyons (Skarke et al., 2014). Multiple areas containing chemosynthetic communities and methane hydrates have been documented within the Exclusive Economic Zone off the northeastern United States (Quattrini et al., 2015). Hydrocarbon seeps are widespread in the Atlantic Ocean basin, including the Gulf of Mexico (Fisher et al., 2007). Seep communities in the Gulf are typically dominated by mussels, polychaete tube worms, and clams (Ross et al., 2012), although numerous other taxa may be present. Communities located in water depths of less than 1,000 m off Louisiana are considered the most intensively studied and well understood seep communities in the world (Bureau of Ocean Energy Management, 2014). There are relatively few bioherms in the northern Gulf of Mexico; most deep-sea corals are found on existing hard substrata. Hundreds of mounds and ridges have been identified along the continental slope off western Florida (Ross et al., 2017). Many of these features that occur in water depths above 525 m appear to be colonized by deep-water corals (primarily *L. pertusa*) and sponges. A rocky scarp running north-to-south along the slope for at least 229 km also supports corals, although at a lower abundance than on the mounds and ridges.

3.4.2.1.2 Movement and Behavior

Marine benthic and epibenthic (animals that live on the surface of the substrate) invertebrates may be sessile, sedentary (limited mobility), or highly mobile (but typically slower than large vertebrates). Several beach invertebrates (e.g., sand crabs, polychaete worms) recruit to beaches during spring and summer and seasonally move to shallow nearshore waters during late fall and winter. Some subtidal epibenthic invertebrates undergo seasonal onshore-offshore migrations associated with reproduction.

Pelagic marine invertebrates include plankton (organisms that do not swim or generally cannot swim faster than water currents) and nekton (active swimmers that can generally swim faster than water currents). Planktonic animals commonly undergo daily migrations to surface waters at dusk and return to deeper waters at dawn. This includes small, microscopic zooplankton and larvae, larger crustaceans (e.g., small shrimp), and jellyfish. Planktonic organisms vary in their swimming abilities, ranging from weak (e.g., larvae) to substantial (e.g., box jellyfish). Nekton such as prawns, shrimps, and squid have relatively strong swimming ability, although they are typically slower than most vertebrate animals.

3.4.2.1.3 Sound Sensing and Production

In general, organisms may detect sound by sensing either the particle motion or pressure component of sound, or both (refer to Appendix D, Acoustic and Explosive Concepts, for an explanation of these sound components). Aquatic invertebrates probably do not detect pressure since many are generally the same density as water and few, if any, have air cavities that would respond to pressure (Budelmann, 1992a; Popper et al., 2001). Marine invertebrates are generally thought to perceive sound via either external sensory hairs or internal statocysts. Many aquatic invertebrates have ciliated “hair” cells that may be sensitive to water movements, such as those caused by currents or water particle motion very close to a sound source (Budelmann, 1992a, 1992b; Mackie & Singla, 2003). This may allow sensing of nearby prey or predators, or help with local navigation. Detection of particle motion is thought to occur in mechanical receptors found on various body parts (Roberts et al., 2016a). Aquatic invertebrates that are able to sense local water movements with ciliated cells include cnidarians, flatworms, segmented worms, molluscs, and arthropods (Budelmann, 1992a, 1992b; Popper et al., 2001). Crustaceans in particular seem to have extensive occurrence of these structures. The sensory capabilities of adult corals are largely limited to detecting water movement using receptors on their tentacles (Gochfeld, 2004), and the exterior cilia of coral larvae likely help them detect nearby water movements (Vermeij et al., 2010).

Some aquatic invertebrates have specialized organs called statocysts that enable an animal to determine orientation, balance, and, in some cases, linear or angular acceleration. Statocysts allow the animal to sense movement and may enable some species, such as cephalopods and crustaceans, to be sensitive to water particle movements associated with sound or vibration (Hu et al., 2009; Kaifu et al., 2008; Montgomery et al., 2006; Normandeau Associates, 2012; Popper et al., 2001). Because any acoustic sensory capabilities, if present, are apparently limited to detecting the local particle motion component of sound (Edmonds et al., 2016), and because water particle motion near a sound source falls off rapidly with distance, aquatic invertebrates are probably limited to detecting nearby sound sources rather than sound caused by pressure waves from distant sources.

In addition to hair cells and statocysts that allow some marine invertebrates to detect water particle motion, some species also have sensory organs called chordotonal organs that can detect substrate vibrations. Chordotonal organs are typically attached to connective tissue of flexible appendages such as antennae and legs (Edmonds et al., 2016). The structures are connected to the central nervous system and can detect some movements or vibrations that are transmitted through substrate.

Available information indicates that aquatic invertebrates are primarily sensitive to low-frequency sounds. Both behavioral and auditory brainstem response studies suggest that crustaceans may sense sounds up to 3 kilohertz (kHz), but greatest sensitivity is likely below 200 hertz (Hz) (Goodall et al., 1990; Lovell et al., 2005; Lovell et al., 2006). Most cephalopods (e.g., octopus and squid) likely sense low-frequency sound below 1 kHz, with best sensitivities at lower frequencies (Budelmann, 1992a; Mooney et al., 2010; Packard et al., 1990). A few cephalopods may sense frequencies up to 1.5 kHz (Hu et al., 2009). Squid did not respond to playbacks of odontocete (e.g., toothed whales) ultrasonic echolocation clicks, likely because these clicks were outside of squid hearing range (Wilson et al., 2007). Although information on the frequency range of the clicks was not provided, ultrasonic sound typically refers to high-frequency sounds above the limit of human hearing (greater than about 20 kHz). Similarly, squid did not respond to killer whale echolocation clicks ranging from 199 to 226 decibels (dB) referenced to 1 micropascal (dB re 1 µPa) (Wilson et al., 2007) (refer to Appendix D, Acoustic and Explosive Concepts, for an explanation of this and other acoustic terms). The frequency of the clicks was not provided. However, killer whale echolocation clicks have been reported to be mostly between 45 and 80 kHz (Au et al., 2004). Some researchers have suggested sensitivity to sounds of higher frequencies in some species, although study results are inconclusive. European spiny lobsters (*Palinurus elephas*), some of which were exposed to predators, were found to produce ultrasound signals up to about 75 kHz (Buscaino et al., 2011). The investigators speculated that the signals might have an anti-predator function or might be used in intraspecific communication, although these functions (particularly communication) were considered hypothetical. The results of another study suggest that European spiny lobsters likely use acoustic signals to aggregate (frequency was not specified, although lobsters in the study produced sounds of up to 30 kHz) (Filiciotto et al., 2014). However, information currently available indicates that invertebrates are likely sensitive only to local water movement and to low-frequency particle accelerations generated in their close vicinity (Normandeau Associates, 2012).

Although many types of aquatic invertebrates produce sound and at least some species have the ability to detect low-frequency particle motion, little is known about the use of sound or whether all sound production is purposeful or merely incidental in some cases (Hawkins et al., 2015; Normandeau Associates, 2012). Some invertebrates have structures that appear to be designed specifically for sound production, and the results of various studies (summarized in the following paragraphs) indicate that sound is used for communication or other behaviors in some species. For example, it has been suggested by numerous researchers that the larvae of some marine species (e.g., crustaceans, molluscs, and corals) use sound cues for directional orientation (Budelmann, 1992a, 1992b; Montgomery et al., 2006; Popper et al., 2001).

Aquatic invertebrates may produce and use sound in territorial behavior, to detect or deter predators, and in reproduction (Popper et al., 2001). Some crustaceans produce sound by rubbing or closing hard body parts together (Au & Banks, 1998; Heberholz & Schmitz, 2001; Latha et al., 2005; Patek & Caldwell, 2006). The snapping shrimp chorus makes up a significant portion of the ambient noise in many locations (Au & Banks, 1998; Cato & Bell, 1992; Heberholz & Schmitz, 2001). Each snapping shrimp click is up to 215 dB re 1 µPa at 1 m (root mean square [rms] is implied, but the authors did not explicitly state sound pressure level [SPL] or peak SPL), with a peak around 2 to 5 kHz. Some crustaceans, such as the American lobster (*Homarus americanus*) and California mantis shrimp (*Hemisquilla californiensis*), may also produce sound by vibrating the carapace (Henninger & Watson, 2005; Patek & Caldwell, 2006). Spiny lobsters typically produce low-frequency rasps by moving a structure at the base of the antennae over a rigid file (Buscaino et al., 2011). Other crustaceans make low-frequency rasping or rumbling noises, perhaps used in defense or territorial display (Patek & Caldwell, 2006; Patek et al., 2009), or perhaps used incidental to a visual display. The aquatic isopod *Cymodoce japonica* produces sound by rubbing body parts together (Nakamachi et al., 2015).

Reef noises, such as fish pops and grunts, sea urchin grazing (around 1 kHz), parrotfish grazing, and snapping shrimp noises (around 5 kHz) (Radford et al., 2010), may be used as a cue by some aquatic invertebrates. Nearby reef noises were observed to affect movements and settlement behavior of coral and crab larvae (Jeffs et al., 2003; Radford et al., 2007; Stanley et al., 2010; Vermeij et al., 2010), although chemical cues and substrate color are also used by some species (Foster & Gilmour, 2016). Larvae of other crustacean species, including pelagic and nocturnally emergent species that benefit from avoiding coral reef predators, appear to avoid reef noises (Simpson et al., 2011). Detection of reef noises is likely limited to short distances. Low-frequency sound pressure and particle motion have been measured near a coral reef off Maui, Hawaii (Kaplan & Mooney, 2016). Results indicate that adult cephalopod species would not be able to detect the low level of particle acceleration at the measurement point nearest the reef (50 m). The specific particle acceleration levels detected by marine invertebrate larvae are unknown, but the authors suggest that invertebrate larvae would be unlikely to detect particle acceleration at distances beyond 150 m at this reef. Playback of reef sounds increased the settlement rate of eastern oyster (*Crassostrea virginica*) larvae (Lillis et al., 2013). Green-lipped mussel (*Perna canaliculus*) larvae settlement rate increased when exposed to underwater noise produced by a ferry (Wilkens et al., 2012).

3.4.2.1.4 General Threats

General threats to marine invertebrates include overexploitation and destructive fishing practices (Halpern et al., 2008; Jackson et al., 2001; Kaiser et al., 2002; Miloslavich et al., 2011; Pandolfi et al., 2003), habitat degradation resulting from pollution and coastal development (Cortes & Risk, 1985; Downs et al., 2009; Mearns et al., 2011), disease (Porter et al., 2001), invasive species (Bryant et al., 1998; Galloway et al., 2009; Wilkinson, 2002) (which may be introduced as a result of growth on vessel hulls or bilge water discharge), oil spills (Yender et al., 2010), global climate change and ocean acidification (Hughes et al., 2003), and possibly human-generated noise (Brainard et al., 2011; Vermeij et al., 2010). A relatively new threat to marine invertebrates is bioprospecting, which is the collection of organisms in pursuit of new compounds for development of pharmaceutical products (Radjasa et al., 2011). Coastal waters of the entire Study Area are subject to intense bioprospecting, although the overall impacts may be minimal (Hunt & Vincent, 2006).

Compared to many other invertebrate taxa, the threats to corals and oysters are well-studied. Numerous natural and human-caused stressors may affect corals, including thermal stress, disease, tropical storms, coastal development and pollution, erosion and sedimentation, tourism/recreation, fishing, trade in coral and live reef species, vessel anchoring or groundings, marine debris, predation, invasive species, military and other security-related activities, and hydrocarbon exploration (National Oceanic and Atmospheric Administration, 2008a, 2008b; Sakashita & Wolf, 2009). Coral bleaching, which occurs when corals expel the symbiotic algae living in their tissues, is a stress response to changes in environmental parameters such as temperature or light. A widespread bleaching event occurred throughout the Caribbean Sea, extending to Florida and the Gulf of Mexico, in 2005 (Wilkinson & Souter, 2008). More recently, bleaching occurred in portions of the Caribbean Sea and off the coast of Florida in 2015 (National Oceanic and Atmospheric Administration, 2016a). In 2016, a mass die-off of corals and other invertebrates (e.g., sponges, urchins, brittle stars, and clams) was documented in the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico (National Oceanic and Atmospheric Administration, 2016b, 2016c). The cause of the die-off is currently unknown. A large disease outbreak was documented in numerous coral species off southeastern Florida in 2014 (Precht et al., 2016). Primary threats to deep-water or cold-water corals include bottom fishing, hydrocarbon exploration, cable and pipeline placement, and waste disposal (e.g., discarded or lost rope and fishing equipment, dredged sediments) (Freiwald et al., 2004). Threats to oysters include habitat degradation (due to fishing practices, terrestrial runoff, coastal development, dredging, and vessel strikes), predation, and disease (Eastern Oyster Biological Review Team, 2007). Overharvesting is currently considered only a minor threat.

Threats related to water quality, marine debris, and climate change are further described in the subsections below.

3.4.2.1.4.1 Water Quality

Invertebrates may be affected by changes in water quality resulting from pollution, turbidity and increased particle deposition that may occur as a result of sediment disturbance, and waste discharge. Stormwater runoff and point source discharges associated with coastal development may introduce pollutants into bays and other nearshore coastal areas. The pollutants may degrade sediment and water quality, which in turn can impact marine invertebrate communities. Sediment disturbance may result from activities such as dredging, which can affect sensitive species such as some corals (Erftemeijer et al., 2012). In addition to dredging, erosion due to storm runoff may cause changes in the frequency or magnitude of sedimentation in areas in proximity to ocean outfalls, estuarine inlets, and major river discharges.

Ship discharges may affect water quality and invertebrates associated with the impacted water. Discharged materials include sewage, bilge water, graywater, ballast water, and solid waste (e.g., food and garbage). Discharges may originate from military, commercial, and recreational vessels. Under provisions of the Clean Water Act, the U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Defense have developed Uniform National Discharge Standards to address discharges from U.S. military vessels. Refer to Section 3.2.1.2.2 (Federal Standards and Guidelines) for more information on water quality, including Uniform National Discharge Standards.

Marine invertebrates can be impacted by exposure to oil due to runoff from land, natural seepage, or accidental spills from offshore drilling/extraction or tankers (White et al., 2012). Reproductive and early life stages are especially sensitive to oil exposure. Factors such as oil type, quantity, exposure time, and season can affect the toxicity level. Experiments using corals indicate that oil exposure can result in death, decreased reproductive success, altered development and growth, and altered behavior (White et al., 2012; Yender et al., 2010). For example, investigations conducted between 2011 and 2014 near the site of the Deepwater Horizon oil spill in the Gulf of Mexico found continuing evidence of injury to gorgonian octocoral colonies (Etnoyer et al., 2016).

3.4.2.1.4.2 Climate Change

The primary concerns of climate change in the context of impacts to marine invertebrates include increased water temperature, ocean acidification, increased frequency or intensity of cyclonic storm events, and sea level rise.

Increases in ocean temperature can lead to coral stress, bleaching, and mortality (Lunden et al., 2014). Bleaching of corals and other invertebrates that contain symbiotic algae in their tissues (e.g., some anemones and clams) is often tied to atypically high sea temperatures (Lough & van Oppen, 2009; National Ocean Service, 2016b). Bleaching events have increased in frequency in recent decades. Coral bleaching on a global scale occurred during the summers of 2014, 2015, and 2016 (Eakin et al., 2016). In addition to elevated sea temperatures, atypically low sea temperatures may also cause mortality to corals and most other reef organisms (Colella et al., 2012; Lirman et al., 2011; National Ocean Service, 2016b), suggesting that widening climate extremes could cause more coral bleaching. In one experiment, three coral species that experienced bleaching had reduced ability to remove sediments from their tissue surface (Bessell-Browne et al., 2017). Response to thermal stress may differ across species or within different environmental contexts, with some species or taxa being more tolerant than others (Bahr et al., 2016; Guest et al., 2016; Hoadley et al., 2015). For example, in the Caribbean Sea, while numerous stony corals may be negatively affected by increased water temperature, some gorgonian corals have been found to persist or increase in abundance under similar conditions (Goulet et al., 2017). The results of one study suggest that some corals may acclimate to increased water temperature over time, exhibiting less temperature sensitivity and resulting bleaching activity (McClanahan, 2017). Skeletal formation of post-settlement individuals of the plate coral *Acropora spicifera* was not affected by increased water temperature (Foster et al., 2016). However, exposure to lowered pH was found to increase the potential for negative effects associated with subsequent water temperature increase in one stony coral species (Towle et al., 2016). In addition to potential physiological effects, the distribution of some invertebrates may be affected by changing water temperature. Northern and southern shifts in the geographic center of abundance of some benthic invertebrates along the U.S. Atlantic coast have occurred over the last 20 years, presumably in response to increased water temperature (Hale et al., 2017).

Ocean acidification has the potential to reduce calcification and growth rates in species with calcium carbonate skeletons, including shellfish (e.g., clams, oysters), corals, and sponges (Cohen et al., 2009), and crustose coralline algae that contain calcite in their cell walls (Roleda et al., 2015). For example, newly settled individuals of the plate coral *A. spicifera* that were exposed to elevated carbon dioxide and lowered pH levels showed decreased mineral deposition and evidence of skeletal malformation (Foster et al., 2016), and water acidification decreased the survival, size, and weight of bay barnacles (*Balanus improvises*) (Pansch et al., 2018). The results of one study suggest that community-level effects to corals can be more evident than effects to individual corals (Carpenter et al., 2018). Many species within these taxa are important structure-building organisms. In addition to corals and shellfish, acidification may also affect weakly calcified taxa such as lobsters and sea cucumbers (Small et al., 2016; Verkaik et al., 2016). Some climate change models predict that the depth below which corals are unable to form calcium carbonate skeletons will become shallower as the oceans acidify and temperatures increase, potentially decreasing the occurrence and habitat-forming function of corals and other invertebrates. Deep-sea scleractinian stony corals could be particularly vulnerable due to habitat loss and decreased larvae dispersal (Fox et al., 2016; Miller et al., 2011). However, a recent study of successive generations of shallow-water reef-building corals exposed to increased water temperature and acidification suggests some corals may be able to tolerate rapidly changing environmental conditions better than previously thought (Putnam & Gates, 2015). In addition to physical effects, increased acidity may result in behavioral changes in some species. For example, acidification of porewater was found to affect burrowing behavior and juvenile dispersal patterns of the soft-shell clam (*Mya arenaria*) (Clements et al., 2016), and increased acidity caused a reduction in the loudness and number of snaps in the snapping shrimp *Alpheus novaezelandiae* (Rossi et al., 2016). As discussed for thermal stress, some invertebrate species may be more tolerant of changing acidity levels than others (Bahr et al., 2016). One study found that lowered pH caused a significant decrease in black band disease progression in mountainous star coral (Muller et al., 2017). Another study of three Arctic marine bivalves concluded that at least two of the species are generally resilient to decreased pH (Goethel et al., 2017). A study of the deep-water stony coral *Desmophyllum dianthus* found that the species was not affected by increased acidity under conditions of ambient water temperature but that stress and decreased calcification occurred when acidity and water temperature were both increased (Murray et al., 2016). Gelatinous invertebrates such as jellyfish generally seem to be tolerant of increased water acidity (Treible et al., 2018).

Although the potential effects that climate change could have on future storm activity is uncertain, numerous researchers suggest that rising temperatures could result in little change to the overall number of storms, but that storm intensity could increase (Voiland, 2013). Increased storm intensity could result in increased physical damage to individual corals and reefs constructed by the corals (which support numerous other invertebrate taxa), overturning of coral colonies, and a decrease in structural complexity due to disproportionate breakage of branching species (Heron et al., 2008; The Nature Conservancy, 2015). However, large storms such as hurricanes may also have positive impacts on corals, such as lowering the water temperature and removing less resilient macroalgae from reef structures, which can overgrow corals.

Sea level rise could affect invertebrates by modifying or eliminating habitat, particularly estuarine and intertidal habitats bordering steep and artificially hardened shorelines (Fujii, 2012). It is possible that intertidal invertebrates would colonize newly submerged areas over time if suitable habitat is present.

Coral reef growth may be able to keep pace with sea level rise because accretion rates of individual corals are generally greater than projected potential rates of sea level rise (The Nature Conservancy, 2016). Corals are currently subjected to tidal fluctuations of up to several meters (The Nature Conservancy, 2015; U.S. Geological Survey, 2016). However, the overall net accretion rate of coral reefs may be much slower than the rate of individual corals, decreasing the overall ability of reefs to keep pace with rising water levels. In addition, the compounding effect of other stressors (e.g., ocean acidification) is unknown. In an evaluation of threats to corals previously petitioned for listing under the ESA, sea level rise was considered a low to medium influence on extinction risk (Brainard et al., 2011).

Additional concerns include the potential for changes in ocean circulation patterns that affect the planktonic food supply of filter- and suspension-feeding invertebrates (e.g., corals) (Etnoyer, 2010). An increase in the future incidence of diseases in marine organisms is also theorized (Harvell et al., 2002). In addition, there is concern that cumulative effects of threats from fishing, pollution, and other human disturbance may reduce the tolerance of corals to global climate change (Ateweberhan & McClanahan, 2010; Ateweberhan et al., 2013).

3.4.2.1.4.3 Marine Debris

Marine debris (especially plastics) is a threat to many marine ecosystems, particularly in coastal waters adjacent to urban development. Microplastics (generally considered to be particles less than 5 millimeters [mm] in size), which may consist of degraded fragments of larger plastic items or intentionally manufactured items (e.g., abrasive plastic beads found in some personal care products or used in blast-cleaning), are of concern because of their durability and potential to enter marine food webs (Setala et al., 2016). Field and laboratory investigations have documented ingestion of microplastics by marine invertebrates including bivalve molluscs; crustacean arthropods such as lobsters, shore crabs, and amphipods; annelid lugworms; and zooplankton (Browne et al., 2013; Setala et al., 2014; Von Moos et al., 2012; Watts et al., 2014). While animals with different feeding modes have been found to ingest microplastics, laboratory studies suggest that filter-feeding and deposit feeding benthic invertebrates are at highest risk (Setala et al., 2016). Refer to Section 3.2 (Sediments and Water Quality) for a more detailed discussion of marine debris and the associated effects on water quality.

Researchers conducted an extensive marine debris survey at selected beach locations from Maine to the southern Florida Atlantic coast (Ribic et al., 2010). The survey found relatively low debris levels in the northern and southern portions of the investigated area but higher amounts of debris and a trend of increasing debris occurrence over time in the mid-Atlantic region. All debris items were identified as either land-based, general-source (e.g., plastic bags and bottles), or ocean-based (e.g., items originating from recreational and commercial fishing, shipping, and tourism activities). No items of military origin were differentiated. An assessment of marine debris collected between 2008 and 2015 in the mid-Atlantic region (Delaware to Virginia) found that the most abundant debris items were plastic, foam, and tobacco-related products (Mid-Atlantic Regional Council On The Ocean, 2015). Overall, plastic was the type of debris most often observed. A study of marine debris in the Gulf of Mexico and U.S. Caribbean Sea (Puerto Rico and U.S. Virgin Islands) conducted from 1996 to 2003 found a decrease in the amount of land-based, ocean-based, and general debris in the eastern Gulf of Mexico and Caribbean (Ribic et al., 2011). A decrease in land-based debris only was noted in the western Gulf of Mexico. Similar to survey results of the U.S. Atlantic coast, the majority of debris items were plastic bottles. U.S. Navy vessels have a zero-plastic discharge policy and return all plastic waste to appropriate disposal or recycling sites onshore.

3.4.2.2 Endangered Species Act-Listed Species

As shown in Table 3.4-1, there are eight species of invertebrates listed as Threatened or Species of Concern under the ESA in the Study Area. Seven coral species listed as threatened are discussed in Sections 3.4.2.2.1 (Elkhorn Coral [*Acropora palmata*]) through Section 3.4.2.2.7 (Rough Cactus Coral [*Mycetophyllia ferox*]). Ivory tree coral (*Oculina varicosa*) is a species of concern. Species of concern are those for which NMFS has some concern regarding status and threats, but for which insufficient information is available to indicate a need to list them under the ESA. The species of concern designation does not impose any procedural or substantive requirements under the ESA. Until recently, the queen conch (*Lobatus gigas*, formerly *Strombus gigas*) was also listed as a species of concern. However, in 2014, NMFS announced that listing the queen conch under the ESA is not warranted (Endangered and Threatened Wildlife and Plants: Notice of 12-Month Finding on a Petition To List the Queen Conch as Threatened or Endangered Under the Endangered Species Act (ESA), 79 *Federal Register* 65628–65643 [November 5, 2014]).

In this section, corals are discussed in terms of individual coral polyps or early life stages, where "coral" is defined as follows: Species of the phylum Cnidaria, including all species of the orders Antipatharia (black corals), Scleractinia (stony corals), Gorgonacea (horny corals), Stolonifera (organ pipe corals and others), Alcyonacea (soft corals), and Helioporacea (blue coral) of the class Anthozoa; and all species of the families Milleporidea (fire corals) and Stylasteridae (stylasterid hydrocorals) of the class Hydrozoa.

NMFS has identified the overall primary factors contributing to decline of coral species listed under the ESA (National Oceanic and Atmospheric Administration Fisheries, 2015). The factors are disease outbreaks; habitat degradation and modification due to sedimentation; increased predation; hurricanes; pollution; introduced species; invasive green algae; limited distribution; damage from mechanical fishing gear, anchors, fish pots, divers, and swimmers; and coral bleaching.

Table 3.4-1: Status and Presence of Endangered Species Act-Listed and Species of Concern Invertebrate Species in the Study Area

Species Name and Regulatory Status			*Location in Study Area[1]*		
Common Name	***Scientific Name***	***Endangered Species Act Listing***	***Open Ocean***	***Large Marine Ecosystem***	***Bays, Harbors, and Inshore Waterways***
Elkhorn coral	*Acropora palmata*	Threatened	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	Florida Bay and Biscayne Bay
Staghorn coral	*Acropora cervicornis*	Threatened	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	Florida Bay and Biscayne Bay
Lobed star coral	*Orbicella annularis*	Threatened	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	Florida Bay and Biscayne Bay
Boulder star coral	*Orbicella franksi*	Threatened	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	Florida Bay and Biscayne Bay

Table 3.4-1: Status and Presence of Endangered Species Act-Listed and Species of Concern Invertebrate Species in the Study Area (continued)

Species Name and Regulatory Status			*Location in Study Area*[1]		
Common Name	***Scientific Name***	***Endangered Species Act Listing***	***Open Ocean***	***Large Marine Ecosystem***	***Bays, Harbors, and Inshore Waterways***
Mountainous star coral	*Orbicella faveolata*	Threatened	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	Florida Bay and Biscayne Bay
Pillar coral	*Dendrogyra cylindrus*	Threatened	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	Florida Bay and Biscayne Bay
Rough cactus coral	*Mycetophyllia ferox*	Threatened	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	Biscayne Bay
Ivory tree coral	*Oculina varicosa*	Species of Concern	None	Gulf of Mexico, Southeast U.S. Continental Shelf, Caribbean Sea	None

[1] Presence in the Study Area is characterized by biogeographic units: open-ocean oceanographic features (Labrador Current, Gulf Stream, and North Atlantic Gyre) or by coastal waters of large marine ecosystems (Caribbean Sea, Gulf of Mexico, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, and West Greenland Shelf) in the Study Area.

3.4.2.2.1 Elkhorn Coral (*Acropora palmata*)

3.4.2.2.1.1 Status and Management

Elkhorn coral is listed as a threatened species under the ESA, and critical habitat has been designated. The critical habitat designation identifies the physical or biological features essential to the species' conservation as "substrate of suitable quality and availability to support larval settlement and recruitment, and reattachment and recruitment of asexual fragments." For purposes of this definition, "substrate of suitable quality and availability" means natural consolidated hard substrate or dead coral skeleton that is free from fleshy or turf macroalgae cover and sediment cover (Endangered and Threatened Species; Critical Habitat for Threatened Elkhorn and Staghorn Corals, 73 *Federal Register* 72210–72241 [November 26, 2008]). This definition applies to depths from mean low water to 30 m. No other essential features were sufficiently definable. The critical habitat designation for elkhorn coral applies to staghorn coral as well (see Section 3.4.2.2.2, Staghorn Coral [*Acropora cervicornis*]). While most shallow-water coral habitat in the Study Area falls within the definition of critical habitat for elkhorn and staghorn coral, the United States contains only about 10 percent of all potential critical habitat in the Caribbean (Bryant et al., 1998). Exemptions from critical habitat designations include a small zone around Naval Air Station Key West and a small area within the South Florida Ocean Measurement Facility Testing Range. The exemption for Naval Air Station Key West was granted in accordance with a provision of the National Defense Authorization Act that allows such exemptions for installations with approved Integrated Natural Resources Management Plans. The exemption for the South Florida Ocean Measurement Facility was granted for national security reasons (73 *Federal Register* 229: 72210–72241, November 26, 2008). However, ESA protection is not limited to critical habitat designations; the species and where it might occur are also protected via regulatory consultation requirements.

The species' four areas of critical habitat are the Florida area (1,329 square miles [mi^2]), the Puerto Rico area (1,383 mi^2), the St. John/St. Thomas area (121 mi^2), and the St. Croix area (126 mi^2) (see Figure 3.4-1). Areas adjacent to the Naval Air Station Key West and within the footprint of the South Florida Ocean Measurement Facility Testing Range include areas that meet the definition of elkhorn critical habitat. However, areas within 50 yards of the shore of Naval Air Station Key West and a small portion of the nearshore footprint of the South Florida Ocean Measurement Facility Testing Range (combined total of 5.5 mi^2) have been exempted from the critical habitat designation (Endangered and Threatened Species; Critical Habitat for Threatened Elkhorn and Staghorn Corals, 73 *Federal Register* 72210–72241 [November 26, 2008]).

3.4.2.2.1.2 Habitat and Geographic Range

Elkhorn coral is typically found on outer reef crests and slopes with exposure to wave action at depths of 1 to 20 m, although it has been reported as deep as 30 m (Aronson et al., 2008b; Boulon et al., 2005). The optimal water temperature range for elkhorn coral is 77 to 84 degrees Fahrenheit, and it requires a salinity range of 34 to 37 parts per thousand (Aronson et al., 2008b; Boulon et al., 2005; Goreau & Wells, 1967). Elkhorn coral inhabits shallow waters with high oxygen content and low nutrient levels (Spalding et al., 2001). Clear, shallow water allows the coral sufficient sunlight exposure to support zooxanthellae (symbiotic photosynthetic organisms; analogous to plants living inside the animals). Elkhorn coral primarily inhabits the seaward margins of reefs where appropriate conditions are more likely to occur (Ginsburg & Shinn, 1964).

Elkhorn corals are typically found in the southeastern part of the Gulf of Mexico Large Marine Ecosystem, the northern part of the Caribbean Sea Large Marine Ecosystem, and the southern part of the Southeast U.S. Continental Shelf Large Marine Ecosystem. Elkhorn coral distribution in the Study Area extends from southeastern Florida through the Florida Keys, and surrounds Puerto Rico and the U.S. Virgin Islands (Aronson et al., 2008b). Elkhorn coral is known to occur in portions of the South Florida Ocean Measurement Facility Testing Range (Gilliam & Walker, 2011) and the Key West Range Complex. Two colonies of elkhorn coral occur in the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico, but this area is not included in designated elkhorn critical habitat (Endangered and Threatened Species; Critical Habitat for Threatened Elkhorn and Staghorn Corals, 73 *Federal Register* 72210–72241 [November 26, 2008]). Although the Flower Garden Banks National Marine Sanctuary is located in the Gulf of Mexico, it does not intersect a training or testing range and would not likely be directly impacted. Therefore, this area is excluded from further analysis.

3.4.2.2.1.3 Population Trends

Elkhorn coral is in the Acroporidae family of corals. A review of quantitative data of Acroporidae in the wider Caribbean area, including the Florida Keys and Dry Tortugas, indicates a greater than 97 percent reduction of Acroporidae coverage since the 1970s with peak declines in the 1980s (Boulon et al., 2005; National Marine Fisheries Service, 2015). Multiple stressors, including disease, increased water temperature, decreased breeding population, loss of recruitment habitat, and sedimentation, may be affecting the recovery of this species. The current range of Acroporidae is considered to be the same as the historical range, despite the more than 97 percent reduction of individual corals (Bruckner, 2003; Rothenberger et al., 2008).

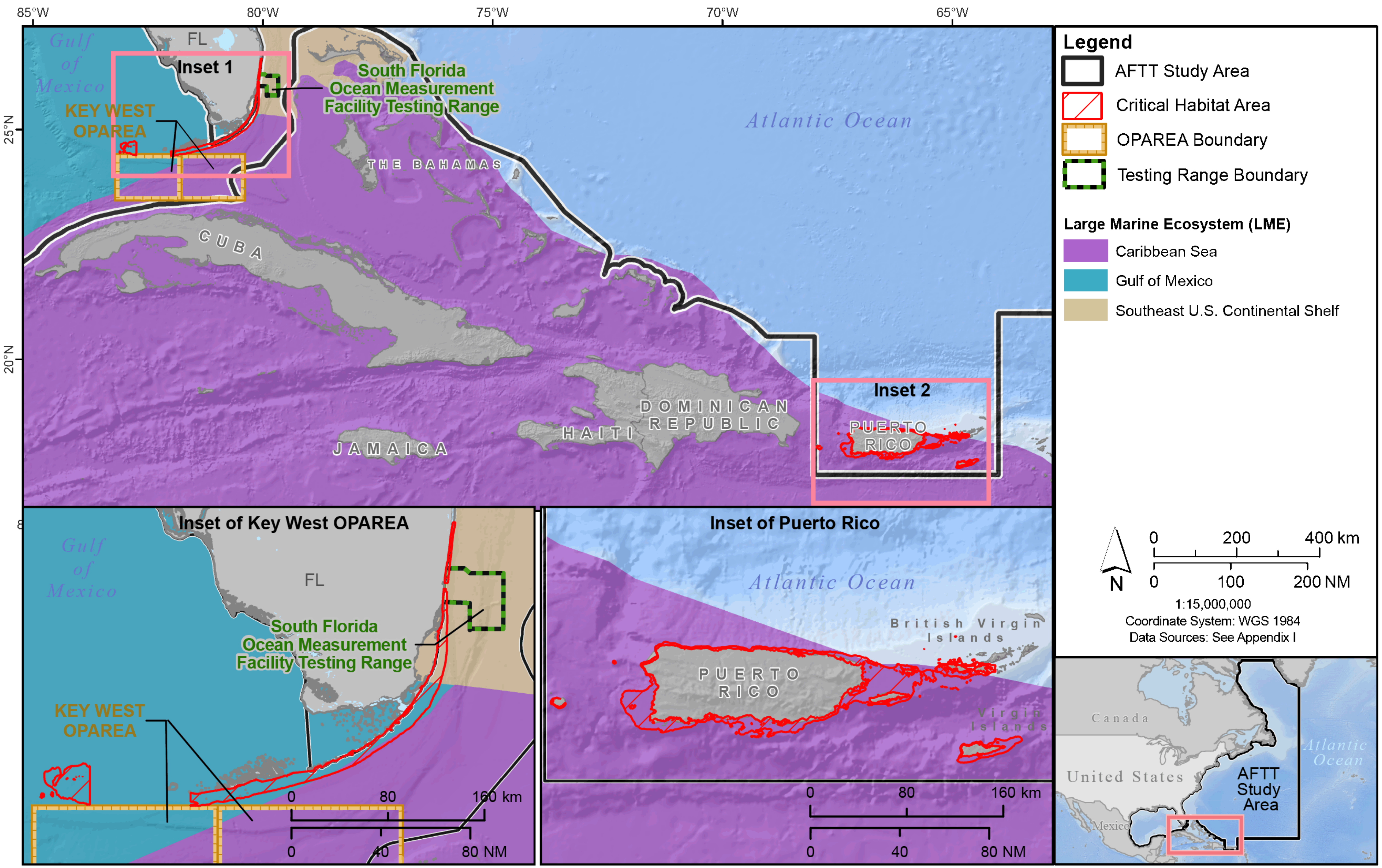
Research on the population status of elkhorn coral in particular indicates a drastic decline. Surveys of Carysfort Reef (1974 to 1982) and Molasses Reef (1981 and 1986) revealed slight declines or stable colonies (Jaap et al., 1988). It was not until the observation of a 93 percent decrease of coral in Looe Key (1983 to 2000) that the elkhorn coral populations mirrored the substantial decline of other coral species such as staghorn coral (Miller et al., 2002). Continued long-term monitoring in the Florida Keys and the U.S. Virgin Islands has found that elkhorn coral remains at less than 1 percent of all corals on reefs (Rothenberger et al., 2008), and the species' continued decline since 2004 is attributed principally to fragmentation, disease, and predation (Williams & Miller, 2011). Notwithstanding the additional focus provided by the 2006 decision to list elkhorn coral as threatened, the population has continued to decline by 50 percent or more, recruitment failure has been observed, and genetic studies have shown that approximately half of all colonies are clones, which reduces the number of genetically distinguishable individuals.

Elkhorn coral can reproduce sexually by spawning (once each year in August or September) (Boulon et al., 2005), or asexually by fragmentation (National Marine Fisheries Service, 2010). Although fragmentation of adult colonies helps maintain high growth rates (from 4 to 11 centimeters (cm) [approximately 2 to 4 inches (in.)] per year), fragmentation reduces the reproductive potential of elkhorn coral by delaying the production of eggs and sperm for 4 years after the damage occurs (Lirman, 2000). Furthermore, large intact colonies produce proportionally more gametes than small colonies (such as new colonies started from fragmentation) because tissue at growing portions of the base and branch tips is not fertile (National Marine Fisheries Service, 2015). During sexual reproduction, eggs and sperm immediately float to the sea surface where multiple embryos can develop from the fragmentation of a single embryo. Developing larvae travel at or near the sea surface for up to several weeks (Boulon et al., 2005) before actively seeking specific micro-habitats suitable for growth. Maturity is reached between 3 and 8 years (Wallace, 1999). The average generation time is 10 years, and longevity is likely longer than 10 years based on average growth rates and size (Aeby et al., 2008). Combined with a severely reduced population, these factors restrict the species' capacity for recovery.

3.4.2.2.1.4 Predator and Prey Interactions

Predators of corals include sea stars, snails, and fishes (e.g., parrotfish and damselfish) (Boulon et al., 2005; Roff et al., 2011). The marine snail, *Coralliophila abbreviata*, and the bearded fireworm (*Hermodice carunculata*), are the primary predators on elkhorn coral (Boulon et al., 2005).

Corals feed on zooplankton, which are small organisms that inhabit the ocean water column. Corals capture prey with tentacles armed with stinging cells that surround the mouth or by employing a mucus-net to catch suspended prey. In addition to capturing prey, these corals also acquire nutrients through their symbiotic relationship with zooxanthellae. The coral host provides nitrogen in the form of waste to the zooxanthellae, and the zooxanthellae provide organic compounds produced by photosynthesis (the process by which sunlight is used to produce food) to the host (Brusca & Brusca, 2003; Schuhmacher & Zibrowius, 1985). Zooxanthellae also provide corals with their characteristic color.



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

Figure 3.4-1: Critical Habitat Areas for Elkhorn and Staghorn Coral Within the Study Area

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3.4.2.2.1.5 Species-Specific Threats

Elkhorn coral is more susceptible to disease than many other Caribbean corals (Pandolfi et al., 2003) (Patterson et al., 2002; Porter et al., 2001). In particular, elkhorn coral is susceptible to a disease named "white pox" or "acroporid serratiosis" caused by a human fecal bacterium (*Serratia marcescens*). The bacterium is present in other coral species, but causes disease only in elkhorn coral (Sutherland et al., 2011). Discharge of sewage from all oceangoing vessels therefore has the potential to expose elkhorn coral to this bacterium. Navy vessel discharges are managed according to established Uniform National Discharge Standards (refer to Section 3.2.1.2.2, Federal Standards and Guidelines, for more information). Elkhorn coral is also susceptible to the same suite of stressors that generally threaten corals (Section 3.4.2.1.4, General Threats).

NMFS evaluated the population's demographic, spatial structure, and vulnerability factors to determine whether the species was likely to have an "…extremely high risk of extinction with little chance for recovery…" by 2100 (Brainard et al., 2011). Elements that contribute to elkhorn coral's threatened listing are: high vulnerability to ocean warming, ocean acidification and disease, high vulnerability to sedimentation and elevated nutrient levels, uncommon abundance, decreasing trend in abundance, low relative recruitment rate, restricted geographic range, concentrated in the Caribbean, and inadequacy of regulatory mechanisms.

3.4.2.2.2 Staghorn Coral (*Acropora cervicornis*)

3.4.2.2.2.1 Status and Management

Staghorn coral is designated as a threatened species under the ESA. Staghorn coral shares the four areas of designated critical habitat with elkhorn coral, as well as the two exemptions at Navy facilities (refer to Section 3.4.2.2.1.1, Status and Management, for information on critical habitat for these two species). Exemptions from critical habitat designations include a small zone around Naval Air Station Key West and a small area within the South Florida Ocean Measurement Facility Testing Range. The exemption for Naval Air Station Key West was granted in accordance with a provision of the National Defense Authorization Act that allows such exemptions for installations with approved Integrated Natural Resources Management Plans. The exemption for the South Florida Ocean Measurement Facility was granted for national security reasons (73 *Federal Register* 229: 72210–72241, November 26, 2008).

3.4.2.2.2.2 Habitat and Geographic Range

Staghorn coral is commonly found in lagoons and the upper to mid-reef slopes, at depths of 1 to 20 m, and requires a salinity range of 34 to 37 parts per thousand (Aronson et al., 2008d; Boulon et al., 2005) (refer to Section 3.4.2.2.1.2, Habitat and Geographic Range, as habitat information provided for elkhorn coral applies to staghorn coral as well).

In the Study Area, staghorn distribution extends south from Palm Beach, Florida and along the east coast to the Florida Keys and Dry Tortugas (Jaap, 1984), in the southern part of the Gulf of Mexico Large Marine Ecosystem, the northern part of the Caribbean Sea Large Marine Ecosystem, and the southern part of the Southeast U.S. Continental Shelf Large Marine Ecosystem. Staghorn coral is known to occur in portions of the Key West Range Complex (Endangered and Threatened Wildlife and Plants: Proposed Listing Determinations for 82 Reef-Building Coral Species; Proposed Reclassification of *Acropora palmata* and *Acropora cervicornis* from Threatened to Endangered, 77 *Federal Register* 73219–73262 [December 7, 2012]).

3.4.2.2.2.3 Population Trends

Most population monitoring of shallow-water corals is focused on the Florida Keys, which straddle three large marine ecosystems: Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico. Because the Florida Keys comprise their own ecological subregion, most reports categorize coral data as Floridian versus Caribbean rather than distinguishing populations on one side of these artificial boundaries. Research on the population status of staghorn coral indicates a drastic decline throughout the Caribbean that peaked in the 1980s. At four long-monitored reefs in the Florida Keys, staghorn coral cover decreased as follows:

- 18 percent on Carysfort Reef (1974 to 1982) (Dustan & Halas, 1987)
- 96 percent on Molasses Reef (1981 to 1986) (Jaap et al., 1988)
- 80 to 98 percent in the Dry Tortugas (Davis, 1982)

Continued long-term monitoring in the Florida Keys and the U.S. Virgin Islands has found that staghorn coral remains at 2 percent or less of all corals on reefs, a fraction of its former abundance (Boulon et al., 2005; Rothenberger et al., 2008) (refer to Section 3.4.2.2.1.3, Population Trends, for general population and abundance information regarding acroporid corals). Staghorn coral grown in “nurseries” to assist recovery programs had substantially higher survival rates after a catastrophic cold-water bleaching event in 2010, suggesting that restoration projects have potential for success (Schopmeyer et al., 2011). This same 2010 cold-water event killed an average of 15 percent of staghorn colonies at monitored reefs in the Florida Keys, a substantial decline in this remnant population (Lirman et al., 2011; National Oceanic and Atmospheric Administration, 2012). Since the 2006 decision to list staghorn coral as threatened, some populations have continued to decline by 50 percent or more, and reliance on asexual fragmentation as a source of new colonies is not considered sufficient to prevent extinction (Endangered and Threatened Wildlife and Plants: Proposed Listing Determinations for 82 Reef-Building Coral Species; Proposed Reclassification of *Acropora palmata* and *Acropora cervicornis* from Threatened to Endangered, 77 *Federal Register* 73219–73262 [December 7, 2012]).

Growth rates for this species range from approximately 1 to 5 in. per year (Boulon et al., 2005). Reproductive strategies and characteristics are not materially different from elkhorn coral (Section 3.4.2.2.1.3, Population Trends).

3.4.2.2.2.4 Predator and Prey Interactions

Predators of corals include sea stars, snails, and fishes (e.g., parrotfish and damselfish) (Boulon et al., 2005; Roff et al., 2011). The marine snail, *Coralliophila abbreviata* (Grober-Dunsmore et al., 2006), and the bearded fireworm, are the primary predators on staghorn coral. Staghorn coral feeding strategies and symbioses are not materially different than those described for elkhorn coral (Section 3.4.2.2.1.4, Predator and Prey Interactions).

3.4.2.2.2.5 Species-Specific Threats

Staghorn coral has no species-specific threats. It is susceptible to the same suite of stressors that generally threaten corals (Section 3.4.2.2.1.5, Species-Specific Threats). However it is more susceptible to disease such as white band disease (Patterson et al., 2002; Porter et al., 2001), even though other diseases also can impact staghorn coral survival (National Marine Fisheries Service, 2015). A white band type II disease which is linked with the bacterial infection, *Vibrio carchariae*, also referred to as *V. charchariae* or *V. harveyi* (Gil-Agudelo et al., 2006), has also been described. A transmissible disease that caused rapid tissue loss in staghorn corals in the Florida Keys was described in 2003 (Williams & Miller, 2005). Similar to white pox in *A. palmata*, the disease manifested with irregular multifocal tissue lesions with apparently healthy tissue remaining in between. Ciliate infections have also been documented at several locations in the Caribbean (Croquer et al., 2006).

NMFS evaluated the population's demographic, spatial structure, and vulnerability factors to determine whether the species was likely to have an "…extremely high risk of extinction with little chance for recovery…" by 2100 (Brainard et al., 2011). Elements that contribute to staghorn coral's threatened status include high vulnerability to ocean warming, ocean acidification and disease, high vulnerability to sedimentation and elevated nutrient levels, uncommon abundance, decreasing trend in abundance, low relative recruitment rate, restricted geographic range, and inadequacy of regulatory mechanisms.

3.4.2.2.3 Lobed Star Coral (*Orbicella annularis*)

3.4.2.2.3.1 Status and Management

Lobed star coral (*Orbicella* [formerly *Montastraea*] *annularis*) is listed as threatened under the ESA. *Orbicella annularis*, boulder star coral (*Orbicella franksi*) and mountainous star coral (*Orbicella faveolata*) have partially overlapping morphological characteristics, particularly in northern sections of their range, making identification less certain than for most other Caribbean corals. While there now is reasonable acceptance that these are three separate and valid species, decades of taxonomic uncertainty and difficult field identification have led many to consider these a single species complex. Consequently, many long-term monitoring data sets and previous ecological studies did not distinguish among the three species, instead pooling them together as "*M. annularis* complex" or "*M. annularis* sensu lato" (Brainard et al., 2011; Jaap et al., 2002; National Marine Fisheries Service, 2012a; Somerfield et al., 2008).

3.4.2.2.3.2 Habitat and Geographic Range

Lobed star coral has been reported from depths of 0.5 to 20 m (Brainard et al., 2011; National Marine Fisheries Service, 2012a). *Orbicella* species, including lobed star coral, occur in most reef habitat types, although less commonly on the reef flat and in the shallow zones formerly dominated by elkhorn coral (Brainard et al., 2011; Goreau, 1959; National Marine Fisheries Service, 2012a). *Orbicella* species are key reef-builders. They are known throughout the Caribbean, Bahamas, and the Flower Garden Banks, but are uncommon or possibly absent from Bermuda.

Within the Study Area, lobed star coral is typically found in the southern and southeastern parts of the Gulf of Mexico Large Marine Ecosystem, the northern part of the Caribbean Sea Large Marine Ecosystem, and the southern part of the Southeast U.S. Continental Shelf Large Marine Ecosystem. Lobed star coral range includes most portions of the Study Area where shallow-water coral reefs occur. The principal areas of coincidence between lobed star coral habitat and the Study Area are near Puerto Rico and south Florida. Lobed star coral is known to occur in the South Florida Ocean Measurement Facility Testing Range, adjacent to the Naval Air Station Key West, and the Key West Range Complex. However, some of this geographic range information is based on ecological studies that identified the *O. annularis* complex rather than specifying *O. annularis* in particular.

3.4.2.2.3.3 Population Trends

Lobed star coral in the U.S. Virgin Islands declined 72 percent during the years from 1988 to 1999 (Edmunds & Elahi, 2007). Declines between 40 and 60 percent were recorded in Puerto Rico, and 80 to 95 percent declines were observed in Florida between the late 1970s and 2003 (Aronson et al., 2008c;

Brainard et al., 2011). However, because many studies in Puerto Rico and Florida did not reliably distinguish between the three species, these changes in abundance should be assumed to apply generally to the *O. annularis* species complex (Brainard et al., 2011). In addition to these declines, the remnant population of *O. annularis* in the Florida Keys was decimated by the 2010 cold-water bleaching event that killed about 56 percent of all *O. annularis* colonies at monitored reefs (Lirman et al., 2011).

All three of the *O. annularis* complex species are hermaphroditic, spawning over 6 to 8 nights following the new moon in late summer (late August to early October) (Brainard et al., 2011). Buoyant gametes are fertilized at the surface. Fertilization success is low and recruitment rates are apparently extremely low. For example, one study found only a single *O. annularis* recruit over 16 years of observation of 12 square meters of reef in Discovery Bay, Jamaica (Hughes & Tanner, 2000). Asexual reproduction by fragmentation is occasionally successful, but in general, reproduction rates of this species are extremely low (Aronson et al., 2008c; Brainard et al., 2011). Genetic studies of boulder star coral found that populations in the eastern and western Caribbean are relatively genetically distinct, suggesting that regional differences in population trends or regulations for corals may influence their populations' genetic diversity (Foster et al., 2012).

Growth rates are approximately 1 cm per year for colonies at depths of less than 12 m and growth rates decrease sharply as depth increases (Brainard et al., 2011). Slow growth coupled with low recruitment rates contribute to the three *O. annularis* complex species' vulnerability to extinction (Brainard et al., 2011).

3.4.2.2.3.4 Predator and Prey Interactions

Lobed star coral is much less susceptible to predation by snails than the *Acropora* species, and although preyed on by parrotfish, the species is not targeted (Brainard et al., 2011; Roff et al., 2011). Lobed star coral, as well as other species of *Orbicella*, is susceptible to yellow band disease (Closek et al., 2014). Yellow band disease progresses slowly, but can cause large die-offs over the course of several seasons. The disease is known to affect several other types of coral and is pervasive in the Caribbean (Closek et al., 2014). Lobed star coral feeding strategies and symbioses are not materially different than those described for elkhorn coral (Section 3.4.2.2.1.4, Predator and Prey Interactions).

3.4.2.2.3.5 Species-Specific Threats

All three species of the *O. annularis* complex are highly susceptible to thermal bleaching, both warm and cool extremes (Brainard et al., 2011; National Oceanic and Atmospheric Administration, 2012). Recently, lobed star coral and mountainous star coral (*O. faveolata*) were found to have higher susceptibility to coral bleaching than many other species (van Hooidonk et al., 2012). Among the 25 coral species assessed after a 2010 cold-water bleaching event in Florida, *O. annularis* was the most susceptible to mortality by a factor of almost two (Lirman et al., 2011). Otherwise, this coral has no species-specific threats, and is susceptible to the same suite of stressors that generally threaten corals (Section 3.4.2.1.4, General Threats). Disease and pollution (e.g., nutrients, herbicides, and pesticides) are the most damaging of the general threats (Brainard et al., 2011; Hughes et al., 2003; Pandolfi et al., 2005).

NMFS evaluated the population's demographic, spatial structure, and vulnerability factors to determine whether the species was likely to have an "…extremely high risk of extinction with little chance for recovery…" by 2100 (Brainard et al., 2011). Elements that contribute to lobed star coral's threatened status are: susceptibility to ocean temperature shifts, disease, sedimentation, elevated nutrient levels, and ocean acidification; susceptibility to trophic effects of fishing; inadequate existing regulatory mechanisms to address global threats; threats by human impacts; decreasing trend in abundance; low relative recruitment rate; narrow overall distribution (based on narrow geographic distribution and moderate depth distribution); the concentration of the species in the Caribbean; and shifts to small size classes via fission and partial mortality of older, larger colonies (National Marine Fisheries Service, 2014).

3.4.2.2.4 Boulder Star Coral (*Orbicella franksi*)

3.4.2.2.4.1 Status and Management

Boulder star coral is designated as a threatened species under the ESA.

This species, previously identified as *Montastraea franksi*, is part of the *O. annularis* complex (identified in Section 3.4.2.2.3, Lobed Star Coral [*Orbicella annularis*]), which also includes lobed star coral and mountainous star coral.

3.4.2.2.4.2 Habitat and Geographic Range

Boulder star coral is found at least as deep as 50 m (Brainard et al., 2011), and is found in most reef environments. The *O. annularis* complex has been reported to at least 70 to 90 m, though only *O. faveolata* and *O. franksi* are likely to occur at these depths. The species is found in Bermuda but otherwise its geographic range is not materially different from *O. annularis*.

Boulder star coral is known to occur in the South Florida Ocean Measurement Facility Testing Range, adjacent to Naval Air Station Key West, and the Key West and Gulf of Mexico Range Complexes. However, some of this geographic range information is based on ecological studies that identified the *O. annularis* complex rather than specifying *O. franksi* in particular.

3.4.2.2.4.3 Population Trends

This species information is assumed not to be materially different from lobed star coral; however, differences may be masked since many ecological studies collected data at the *O. annularis* complex level rather than specifying *O. franksi* in particular.

3.4.2.2.4.4 Predator and Prey Interactions

This species information is assumed not to be materially different from lobed star coral; however, differences may be masked since many ecological studies collected data at the *O. annularis* complex level rather than specifying *O. franksi* in particular.

3.4.2.2.4.5 Species-Specific Threats

Boulder star coral was less susceptible to mortality after a 2010 cold-water bleaching event in Florida than any of its congeners (different species of the same genus) by at least a factor of three (Lirman et al., 2011). Otherwise, susceptibility to threats is not assumed to be materially different from lobed star coral. However, differences may be masked because many ecological studies identified the *O. annularis* complex rather than specifying *O. franksi* in particular.

NMFS evaluated the population's demographic, spatial structure, and vulnerability factors to determine whether the species was likely to have an "…extremely high risk of extinction with little chance for recovery…" by 2100 (Brainard et al., 2011). Elements that contribute to boulder star coral's threatened status are: high susceptibility to ocean warming, disease, elevated nutrient levels, ocean acidification, and sedimentation; susceptibility to trophic effects of fishing; inadequate existing regulatory mechanisms to address global threats; threats by human impacts; decreasing trend in abundance; slow growth rate; low relative recruitment rate; moderate overall distribution (based on narrow geographic distribution and wide depth distribution); restriction to the Caribbean; and shifts to small size classes via fission and partial mortality of older, larger colonies (National Marine Fisheries Service, 2014).

3.4.2.2.5 Mountainous Star Coral (*Orbicella faveolata*)

3.4.2.2.5.1 Status and Management

Mountainous star coral is designated as a threatened species under the ESA.

The species was previously identified as *Montastraea faveolata*. Mountainous star coral is part of the *O. annularis* complex (identified in Section 3.4.2.2.3.1, Status and Management), which also includes lobed star coral and boulder star coral.

3.4.2.2.5.2 Habitat and Geographic Range

Mountainous star coral occurs within depths from 0.5 m to at least 40 m (Brainard et al., 2011), and like *O. annularis* it is more commonly found in the shallower portions of this depth range. The *O. annularis* complex has been reported to at least 70 to 90 m, though only *O. faveolata* and *O. franksi* are likely to occur at these depths. This species is found in Bermuda but otherwise its geographic range is not materially different from *O. annularis*.

Mountainous star coral is known to occur in the South Florida Ocean Measurement Facility Testing Range, adjacent to the Naval Air Station Key West, and the Key West Range Complex. However, some of this geographic range information is based on ecological studies that identified the *O. annularis* complex rather than specifying *O. faveolata* in particular.

3.4.2.2.5.3 Population Trends

This species information is assumed not to be materially different from lobed star coral; however, differences may be masked since many ecological studies collected data at the *O. annularis* complex level rather than specifying *O. faveolata* in particular.

3.4.2.2.5.4 Predator and Prey Interactions

This species information is assumed not to be materially different from lobed star coral; however, differences may be masked since many ecological studies collected data at the *O. annularis* complex level rather than specifying *O. faveolata* in particular.

3.4.2.2.5.5 Species-Specific Threats

This species information is assumed not to be materially different from lobed star coral; however, differences may be masked since many ecological studies collected data at the *O. annularis* complex level rather than specifying *O. faveolata* in particular.

NMFS evaluated the population's demographic, spatial structure, and vulnerability factors to determine whether the species was likely to have an "…extremely high risk of extinction with little chance for recovery…" by 2100 (Brainard et al., 2011). Elements that contribute to mountainous star coral's threatened status are: high susceptibility ocean warming, disease, sedimentation and elevated nutrient levels; susceptibility to trophic effects of fishing; inadequate existing regulatory mechanisms to address global threats; decreasing trend in abundance; low relative recruitment rate; late reproductive maturity; moderate overall distribution with concentration in areas of high human impact; and shifts to small size classes via fission and partial mortality of older, larger colonies (National Marine Fisheries Service, 2014).

3.4.2.2.6 Pillar Coral (*Dendrogyra cylindrus*)

3.4.2.2.6.1 Status and Management

Pillar Coral is designated as a threatened species under the ESA.

3.4.2.2.6.2 Habitat and Geographic Range

Pillar coral most frequently occurs at depths of 3 to 8 m but has been documented at depths of 1 to 25 m (Brainard et al., 2011; National Oceanic and Atmospheric Administration, 2012). It is found on rocky outcrops in areas of high wave activity (Marhaver et al., 2015). It is known to occur in south Florida as far north as Broward County and from one colony in Bermuda, but is not known to occur at the Flower Garden Banks or elsewhere in the northern or western Gulf of Mexico.

Within the Study Area, pillar corals are typically found in the southern and southeastern parts of the Gulf of Mexico Large Marine Ecosystem, the northern part of the Caribbean Sea Large Marine Ecosystem, and the southern part of the Southeast U.S. Continental Shelf Large Marine Ecosystem. Pillar coral range includes most portions of the Study Area where shallow-water coral reefs occur. The principal areas of coincidence between pillar coral habitat and the Study Area are near Puerto Rico and south Florida. Pillar coral is known to occur in portions of the South Florida Ocean Measurement Facility Testing Range, adjacent to the Naval Air Station Key West, and the Key West Range Complex.

3.4.2.2.6.3 Population Trends

Pillar coral is both rare and conspicuous (due to its growth form). It has a limited habitat preference and colonies are often dispersed and isolated throughout the habitat range (National Marine Fisheries Service, 2014). Because pillar coral colonies have been killed by warm and cold water bleaching, disease, and physical damage, it has been assumed that this rare species is in decline. In general, pillar coral is too rare for meaningful trends in abundance to be detected by typical reef monitoring programs (Brainard et al., 2011). However, recent studies on reproductive strategies and life history have shown low sexual recruitment rates and slow growth, adding further population and genetic diversity concerns for the species (Marhaver et al., 2015).

Growth rates for this species are typically 8 mm (0.3 in.) per year, though rates up to 20 mm (0.8 in.) per year have been reported (Brainard et al., 2011). Pillar coral spawns, and the first observation of spawning activity was recorded in August 2012, 3 to 4 days after a full moon. Further studies found this spawning activity to be consistent through 2014 (Marhaver et al., 2015). The rate of sexual reproduction is likely to be low because the species is so rare and colonies are gonochoric (i.e., a colony is either male or female); male and female colonies are unlikely to be in close enough proximity for reliable fertilization. For this reason, no juveniles of pillar coral have been observed in the past several decades, and fragmentation seems to be the only successful mode of reproduction for this species (National Marine Fisheries Service, 2012a).

3.4.2.2.6.4 Predator and Prey Interactions

Predators of this species seem to be few, and though the corallivorous fireworm (*Hermodice carunculata*) feeds on diseased pillar coral, it does not seem to be a major predator (Brainard et al., 2011). A species of sea urchin (*Diadema antillarum*) has been known to cause partial mortality at the base of pillar coral colonies (National Marine Fisheries Service, 2014). Pillar coral is distinctive among Caribbean corals because its tentacles are extended for feeding on zooplankton during the day, while most other corals' tentacles are retracted during the day (Boulon et al., 2005; Brainard et al., 2011).

Pillar coral feeding strategies and symbioses are not materially different than those described for elkhorn coral (Section 3.4.2.2.1.4, Predator and Prey Interactions).

3.4.2.2.6.5 Species-Specific Threats

Pillar coral has no species-specific threats. It is susceptible to the same suite of stressors that generally threaten corals (Section 3.4.2.1.4, General Threats); however, it was historically more susceptible to exploitation by the curio trade (Brainard et al., 2011). Low population density and separation of male and female colonies are the principal threats to the species (Brainard et al., 2011; National Marine Fisheries Service, 2012a).

NMFS evaluated the population's demographic, spatial structure, and vulnerability factors to determine whether the species was likely to have an "…extremely high risk of extinction with little chance for recovery…" by 2100 (Brainard et al., 2011). Elements that contribute to pillar coral's threatened status are: susceptibility to ocean warming, disease, acidification, elevated nutrient levels, sedimentation, and trophic effects of fishing; inadequate existing regulatory mechanisms to address global threats; threats by human impacts; rare general range-wide abundance; low relative recruitment rate; narrow overall distribution (based on narrow geographic distribution and moderate depth distribution); and restriction to the Caribbean (National Marine Fisheries Service, 2014).

3.4.2.2.7 Rough Cactus Coral (*Mycetophyllia ferox*)

3.4.2.2.7.1 Status and Management

Rough cactus coral is designated as a threatened species under the ESA.

3.4.2.2.7.2 Habitat and Geographic Range

Rough cactus coral is known to occur as deep as 80 to 90 m (Brainard et al., 2011; National Marine Fisheries Service, 2012a). Though reported to commonly occur at depths of 5 to 30 m (Aronson et al., 2008a), this could be an artifact of scuba diver-based survey intensity, which decreases dramatically below 30 m. Rough cactus coral occurs in patch and fore reef (the part of the reef exposed to the open ocean) habitat types, generally in lower energy parts of the reef (Brainard et al., 2011; National Marine Fisheries Service, 2012a). It is known to occur throughout the Caribbean and southern Gulf of Mexico, but is absent from the Flower Garden Banks, Bermuda, and the southeast United States north of south Florida (National Marine Fisheries Service, 2014).

Within the Study Area, rough cactus coral is typically found in the southern and southeastern parts of the Gulf of Mexico Large Marine Ecosystem, the northern part of the Caribbean Sea Large Marine Ecosystem, and the southern part of the Southeast U.S. Continental Shelf Large Marine Ecosystem. Rough cactus coral range includes most portions of the Study Area where shallow-water coral reefs occur. The principal areas of coincidence between rough cactus coral habitat and the Study Area are near Puerto Rico and south Florida. Rough cactus coral is known to occur in the South Florida Ocean Measurement Facility Testing Range, adjacent to the Naval Air Station Key West, and the Key West Range Complex.

3.4.2.2.7.3 Population Trends

Though probably never abundant, rough cactus coral in the Florida Keys has declined by at least 80 percent since 1996 and perhaps by much more since the 1970s (Brainard et al., 2011). The abundance of rough cactus coral has been estimated to be at least hundreds of thousands of colonies in the Florida Keys and Dry Tortugas (National Marine Fisheries Service, 2014).

Rough cactus coral is a hermaphroditic brooder, releasing fully-developed larvae in the late winter (February to March) (Aronson et al., 2008a). Recruitment rates are extremely low or absent, as evidenced by observation of anchor-damaged site in the U.S. Virgin Islands over a 10-year period (Brainard et al., 2011). No colonies of rough cactus coral were observed to recruit to the site despite the presence of adults on an adjacent reef (National Marine Fisheries Service, 2014).

3.4.2.2.7.4 Predator and Prey Interactions

Rough cactus coral is not known to be particularly susceptible to predators (Brainard et al., 2011), and feeding strategies and symbioses are not materially different than those described for elkhorn coral (Section 3.4.2.2.1.4, Predator and Prey Interactions).

3.4.2.2.7.5 Species-Specific Threats

Though not especially susceptible to mortality from warm-water bleaching (Brainard et al., 2011; Lough & van Oppen, 2009), 15 percent of *Mycetophyllia* species were killed after a cold-water bleaching event in Florida (Lirman et al., 2011). Some coral diseases are characterized by the white-colored bands or pox they cause, but are otherwise difficult to discriminate (Porter et al., 2001). While diseases such as "white plague" do not seem to be species-specific (Porter et al., 2001), rough cactus coral in the Florida Keys has been particularly susceptible to this type of disease (Brainard et al., 2011).

NMFS evaluated the population's demographic, spatial structure, and vulnerability factors to determine whether the species was likely to have an "…extremely high risk of extinction with little chance for recovery…" by 2100 (Brainard et al., 2011). Elements that contribute to rough cactus coral's (*Mycetophyllia ferox*) threatened status are: high susceptibility to disease; susceptibility to ocean warming, acidification, trophic effects of fishing, elevated nutrient levels, and sedimentation; inadequate existing regulatory mechanisms to address global threats; threats by human impacts; rare general range-wide abundance; decreasing trend in abundance; low relative recruitment rate; moderate overall distribution (based on narrow geographic distribution and wide depth distribution); and restriction to the Caribbean (National Marine Fisheries Service, 2014).

3.4.2.3 Species Not Listed Under the Endangered Species Act

Thousands of invertebrate species occur in the Study Area; however, the only species with ESA status are seven coral species listed as threatened and one coral species designated as a species of concern. The variety of species spans many taxonomic groups (taxonomy is a method of classifying and naming organisms). Many species of marine invertebrates are commercially or recreationally fished. Several species are federally managed as part of fisheries under the Magnuson-Stevens Fishery Conservation and Management Act.

Marine invertebrates are classified within major taxonomic groups, generally referred to as a phylum. Major invertebrate phyla—those with greater than 1,000 species (Roskov et al., 2015; World Register of Marine Species Editorial Board, 2015)—and the general zones they inhabit in the Study Area are listed in Table 3.4-2. Vertical distribution information is generally shown for adults; the larval stages of most of the species occur in the water column. In addition to the discrete phyla listed, there is a substantial variety of single-celled organisms, commonly referred to as protozoan invertebrates, that represent several phyla (Kingdom Protozoa in Table 3.4-2). Throughout the invertebrates section, organisms may be referred to by their phylum name or, more generally, as marine invertebrates.

Table 3.4-2: Major Taxonomic Groups of Marine Invertebrates in the Atlantic Fleet Training and Testing Study Area

Table 3.4-2: Major Taxonomic Groups of Marine Invertebrates in the Atlantic Fleet Training and Testing Study Area (continued)

Major Invertebrate Groups[1]		*Presence in the Study Area*[2]		
Common Name (Classification)[3]	***Description***[4]	***Open Ocean Areas***	***Large Marine Ecosystems***	***Inshore Waters***
Foraminifera, radiolarians, ciliates (Kingdom Protozoa)	Benthic and planktonic single-celled organisms; shells typically made of calcium carbonate or silica.	Water column, bottom	Water column, bottom	Water column, bottom
Sponges (Porifera)	Mostly benthic animals; sessile filter feeders; large species have calcium carbonate or silica structures embedded in cells to provide structural support.	Bottom	Bottom	Bottom
Corals, anemones, hydroids, jellyfish (Cnidaria)	Benthic and pelagic animals with stinging cells; sessile corals are main builders of coral reef frameworks.	Water column, bottom	Water column, bottom	Water column, bottom
Flatworms (Platyhelminthes)	Mostly benthic; simplest form of marine worm with a flattened body.	Water column, bottom	Water column, bottom	Water column, bottom
Ribbon worms (Nemertea)	Benthic marine worms with an extendable, long tubular-shaped extension (proboscis) that helps capture food.	Water column, bottom	Bottom	Bottom
Round worms (Nematoda)	Small benthic marine worms; free-living or may live in close association with other animals.	Water column, bottom	Water column, bottom	Water column, bottom
Segmented worms (Annelida)	Mostly benthic, sedentary to highly mobile segmented marine worms (polychaetes); free-living and tube-dwelling species; predators, scavengers, herbivores, detritus feeders, deposit feeders, and filter or suspension feeders.	Bottom	Bottom	Bottom
Bryozoans (Bryzoa)	Small, colonial animals with gelatinous or hard exteriors with a diverse array of growth forms; filter feeding; attached to a variety of substrates (e.g., rocks, plants, shells or external skeletons of invertebrates.	Bottom	Bottom	Bottom

Table 3.4-2: Major Taxonomic Groups of Marine Invertebrates in the Atlantic Fleet Training and Testing Study Area (continued)

Major Invertebrate Groups[1]		***Presence in the Study Area[2]***		
Common Name (Classification)[3]	***Description[4]***	***Open Ocean Areas***	***Large Marine Ecosystems***	***Inshore Waters***
Cephalopods, bivalves, sea snails, chitons (Mollusca)	Soft-bodied benthic or pelagic predators, filter feeders, detritus feeders, and herbivore grazers; many species have a shell and muscular foot; in some groups, a ribbon-like band of teeth is used to scrape food off rocks or other hard surfaces.	Water column, bottom	Water column, bottom	Water column, bottom
Shrimp, crabs, lobsters, barnacles, copepods (Arthropoda)	Benthic and pelagic predators, herbivores, scavengers, detritus feeders, and filter feeders; segmented bodies and external skeletons with jointed appendages.	Water column, bottom	Water column, bottom	Water column, bottom
Sea stars, sea urchins, sea cucumbers (Echinodermata)	Benthic animals with endoskeleton made of hard calcareous structures (plates, rods, spicules); five-sided radial symmetry; many species with tube feet; predators, herbivores, detritus feeders, and suspension feeders.	Bottom	Bottom	Bottom

[1] Major species groups (those with more than 1,000 species) are based on the World Register of Marine Species (World Register of Marine Species Editorial Board, 2015) and Catalogue of Life (Roskov et al., 2015).
[2] Presence in the Study Area includes open ocean areas; large marine ecosystems; and bays, rivers, and estuaries. Occurrence on or within seafloor (bottom or benthic) or water column (pelagic) pertains to juvenile and adult stages; however, many phyla may include pelagic planktonic larval stages.
[3] Classification generally refers to the rank of phylum, although Protozoa is a traditionally recognized group of several phyla of single-celled organisms (e.g., historically referred to as Kingdom Protozoa, which is still retained in some references, such as in the Integrated Taxonomic Information System).
[4] benthic = a bottom-dwelling organism associated with seafloor or substrate; planktonic = an organism (or life stage of an organism) that drifts in pelagic (water) environments; nekton = actively swimming pelagic organism.

Additional information on the biology, life history, and conservation of marine invertebrates can be found on the websites maintained by the following organizations:

- NMFS, particularly for ESA-listed species and species of concern
- United States Coral Reef Task Force
- MarineBio Conservation Society

3.4.2.3.1 Foraminifera, Radiolarians, Ciliates (Kingdom Protozoa)

Foraminifera, radiolarians, and ciliates are miniscule singled-celled organisms, sometimes forming colonies of cells, belonging to the kingdom Protozoa (Appeltans et al., 2010; Castro & Huber, 2000b). They are found in the water column and on the bottom of the world's oceans, and while most are microscopic, some species grow to approximately 20 cm (Hayward et al., 2016). In general, the distribution of foraminifera, radiolarians, and ciliates is patchy, occurring in regions with favorable growth conditions.

Foraminifera form diverse and intricate shells out of calcium carbonate, organic compounds, or sand or other particles cemented together (University of California Berkeley, 2010d). The shells of foraminifera that live in the water column eventually sink to the bottom, forming soft bottom sediments known as foraminiferan ooze. Foraminifera feed on diatoms and other small organisms. Their predators include copepods and other zooplankton.

Radiolarians are microscopic zooplankton that form shells made of silica. Radiolarian ooze covers large areas of soft bottom habitat on the ocean floor (Pearse et al., 1987; University of California Berkeley, 2010b). Many radiolarian species contain symbiotic dinoflagellates (a type of single-celled organism) or algae. Radiolarians may also trap small particles or other organisms (e.g., diatoms) that drift in the water column.

Ciliates are protozoans with small hair-like extensions that are used for feeding and movement. They are a critical food source for primary consumers and are considered important parasites of many marine invertebrates. Ciliates feed on bacteria and algae, and some species contain symbiotic algae.

3.4.2.3.2 Sponges (Phylum Porifera)

Sponges include approximately 8,550 marine species worldwide and are classified in the Phylum Porifera (Van Soest et al., 2012; World Register of Marine Species Editorial Board, 2015). Sponges are bottom-dwelling, multicellular animals that can be best described as an aggregation of cells that perform different functions. Sponges are largely sessile, and are common throughout the Study Area at all depths. Sponges are typically found on intermediate bottoms (unconsolidated substrate that is mostly gravel or cobble-sized) to hard bottoms, artificial structures, and biotic reefs. Sponges reproduce both sexually and asexually. Water flow through the sponge provides food and oxygen, and removes wastes (Pearse et al., 1987; University of California Berkeley, 2010c). This filtering process is an important coupler of processes that occur in the water column and on the bottom (Perea-Blázquez et al., 2012). Many sponges form calcium carbonate or silica spicules or bodies embedded in cells to provide structural support (Castro & Huber, 2000a; Van Soest et al., 2012). Sponges provide homes for a variety of animals including shrimp, crabs, barnacles, worms, brittle stars, sea cucumbers, and other sponges (Colin & Arneson, 1995b). Within the western Atlantic coral reef and related ecosystems, there are 117 genera of sponges (Spalding et al., 2001). Some sponge species are harvested commercially. For example, the sheepswool sponge (*Hippiospongia lachne*) and yellow sponge (*Cleona celata*) are commercially harvested in Florida waters located in the Gulf of Mexico Large Marine Ecosystem (Stevely & Sweat, 2008).

Most sponges do not form reefs because their skeletons do not persist intact after the colony's death. However, the skeletal structure of a few hexactinellid sponge species may form reefs or mounds. Sponge reefs are currently only known off the western coast of Canada. Hexactinellid sponges were documented on bottom features along the shelf break and on Mytilus Seamount in the Northeast U.S. Continental Shelf Large Marine Ecosystem, but reef structures were not reported (Quattrini et al., 2015). Known threats to reef-building sponges are physical strike and disturbance from anthropogenic activities (Whitney et al., 2005).

3.4.2.3.3 Corals, Hydroids, Jellyfish (Phylum Cnidaria)

There are over 10,000 marine species within the phylum Cnidaria worldwide (World Register of Marine Species Editorial Board, 2015), although there is taxonomic uncertainty within some groups (Veron, 2013). Cnidarians are organized into four classes: Anthozoa (corals, sea anemones, sea pens, sea pansies), Hydrozoa (hydroids and hydromedusae), Scyphozoa (true jellyfish), and Cubozoa (box jellyfish, sea wasps). Individuals are characterized by a simple digestive cavity with an exterior mouth surrounded by tentacles. Microscopic stinging capsules known as nematocysts are present (especially in the tentacles) in all cnidarians and are a defining characteristic of the phylum. The majority of species are carnivores that eat zooplankton, small invertebrates, and fishes. However, many species feed on plankton and dissolved organic matter, or contain symbiotic dinoflagellate algae (zooxanthellae) that produce nutrients by photosynthesis (Brusca & Brusca, 2003; Dubinsky & Berman-Frank, 2001; Lough & van Oppen, 2009; National Oceanic and Atmospheric Administration & NOAA's Coral Reef Conservation Program, 2016). Representative predators of cnidarians include sea slugs, snails, crabs, sea stars, coral- and jellyfish-eating fish, and marine turtles. Cnidarians may be solitary or may form colonies.

Cnidarians have many diverse body shapes, but may generally be categorized as one of two basic forms: polyp and medusa. The polyp form is tubular and sessile, attached at one end with the mouth surrounded by tentacles at the free end. Corals and anemones are examples of the polyp form. The medusa form is bell- or umbrella-shaped (e.g., jellyfish), with tentacles typically around the rim. The medusa form generally is pelagic, although there are exceptions. Many species alternate between these two forms during their life cycle. All cnidarian species are capable of sexual reproduction, and many cnidarians also reproduce asexually. The free-swimming larval stage is usually planktonic, but is benthic in some species.

A wide variety of cnidarian species occur throughout the Study Area at all depths and in most habitats, including hard and intermediate shores; soft, intermediate, and hard bottom; aquatic vegetation beds; and artificial substrates. Some cnidarians form biotic habitats that harbor other animals and influence ecological processes, the primary examples being shallow-water and deep-water stony corals.

ESA-listed coral species are primarily associated with shallow-water coral reefs. In the Study Area, shallow-water coral reefs occur in the southern part of the Gulf of Mexico Large Marine Ecosystem, throughout the Caribbean Sea Large Marine Ecosystem, and in the southern part of the Southeast U.S. Continental Shelf Large Marine Ecosystem, including southeast Florida and the Bahamas (Spalding et al., 2001). In the central and eastern part of the Gulf of Mexico Large Marine Ecosystem, coral reefs occur in the Flower Garden Banks National Marine Sanctuary, Pulley Ridge Ecological Reserve, Dry Tortugas Ecological Reserve, and Florida Keys (Monaco et al., 2008; Spalding et al., 2001; U.S. Department of the Navy, 2007; U.S. Geological Survey, 2013). In the Southeast U.S. Continental Shelf Large Marine Ecosystem, shallow-water coral reefs occur throughout the Florida Keys and southeast Florida (Burke & Maidens, 2004). Reefs also occur in the Caribbean Sea Large Marine Ecosystem surrounding Puerto Rico and the U.S. Virgin Islands. Several Caribbean coral species are listed under the ESA (Sections 3.4.2.2.1, Elkhorn Coral [*Acropora palmata*] to Section 3.4.2.2.7, Rough Cactus Coral [*Mycetophyllia ferox*]).

Corals that are associated with tropical shallow reefs and temperate rocky habitats are vulnerable to a range of threats, including fishing impacts, pollution, erosion/sedimentation, coral harvesting, vessel damage, temperature increase, and climate change. Fishing practices such as blast fishing and trapping may be particularly destructive to coral reefs. In addition, removal of herbivorous fishes may result in overgrowth of coral reefs by algae (DeMartini & Smith, 2015). Corals associated with shallow-water reefs in the Florida Keys and some areas of the Caribbean have been substantially degraded by human activities and other factors. Threats are further discussed in Section 3.4.2.1.4 (General Threats) and in the individual descriptions of ESA-listed coral species. Because corals are slow growing and can survive for hundreds of years (Love et al., 2007; Roberts & Hirshfield, 2003), recovery from damage could take many years. Corals that occur in association with shallow-water coral reefs are protected by Executive Order 13089, Coral Reef Protection, and managed by the Coral Reef Task Force (Executive Order 13089: Coral Reef Protection, 63 *Federal Register* 32701–32703 [June 16, 1998]). The Navy is the U.S. Department of Defense representative to the United States Coral Reef Task Force and also carries out the Coral Reef Protection Implementation Plan (Lobel & Lobel, 2000).

Deep-water corals are azooxanthellate (lack symbiotic algae) and thus do not form consolidated biogenic substrate, but rather form mounds of intermediate substrate over hard bottom areas. Deep-water coral taxa in the Study Area consist primarily of hexacorals (stony corals, black corals, and gold corals), octocorals (e.g., true soft corals, gorgonians, sea pens), and hydrocorals (e.g., lace corals) (Hourigan et al., 2017a). A total of 77 deep-water coral species have been identified off the northeastern United States from Maine to North Carolina, including the continental shelf and slope of the Gulf of Maine, Georges Bank, southern New England, Mid-Atlantic Bight (to Cape Hatteras), and various seamounts located off New England near Georges Bank (Packer et al., 2017). The majority of these coral species consist of gorgonians. Soft corals are more common at shallower sites. Large bioherm formations resulting from stony coral species such as *L. pertusa* have not been observed in the northeast region. Numerous submarine canyons, which often contain hard substrate necessary for most deep-water corals, occur on the continental slope and shelf from Georges Bank to Cape Hatteras. Available information indicates that deep-water corals are more densely distributed in canyons than on the adjacent slope, although there is considerable variation between individual canyons (Packer et al., 2017). Colonial and solitary stony corals, black corals, and gorgonians have often been observed on hard substrate within the canyons, while solitary stony corals, sea pens, and bamboo corals are common on soft sediments. Overall, gorgonians appear to be the dominant structure-forming corals. Deep-sea coral occurrence in canyons along Georges Bank and the Mid-Atlantic Bight generally extends from depths of about 200 m to below 2,000 m. Corals were generally found to be uncommon in most open slope and inter-canyon sites, with the exception of some soft-sediment areas that supported sea pens and bamboo corals (Quattrini et al., 2015). Corals and deep-sea sponges were also observed on boulders and outcrops in some open slope and inter-canyon areas. Multiple seamount areas off the northeastern United States have been explored in recent years (Packer et al., 2017; Quattrini et al., 2015). Species composition was different among the various seamounts but generally included sea pens and stony cups corals in soft-sediment areas, and taxa such as black corals and gorgonians on hard bottom, walls, ledges, and rocky outcrops. Exploratory surveys in the Gulf of Maine have documented extensive coral aggregations in surveyed areas at depths of about 200 to 250 m. Structure-forming corals at these sites consisted mostly of gorgonians. Dense sea pen patches were observed in some mud and gravel habitats adjacent to hard bottom habitats. Two of the surveyed sites that support dense coral growth (Outer Schoodic Ridge and Mount Desert Rock) occur in the inshore portion of the Gulf of Maine, approximately 20 to 25 nautical miles (NM) from the coast. In 2016, the Northeast Canyons and Seamounts Marine National Monument was designated. The monument consists of two units, with one unit encompassing three canyons on the edge of Georges Bank and the other encompassing four seamounts. Designation of the monument is intended to protect deep-sea corals, among other resources.

In the southeastern U.S. region (Cape Hatteras, North Carolina to the Straits of Florida, including deep water areas such as Blake Plateau), deep-water stony corals reach their greatest abundance and structure formation in U.S. waters (Hourigan et al., 2017b). Research has been more extensive in this area than in the northeast United States, although many of the deeper portions remain poorly explored. A total of 197 deep-water coral species have been identified off the southeastern United States. Most of these species consist of stony and gorgonian corals. Broadly, the major concentrations of hard bottom habitat that are known to support or likely support deep-water corals off the southeastern United States include the continental shelf break, *Oculina* coral mounds, the continental slope and Blake Plateau, and the Miami and Pourtales Terraces and Escarpments. High relief ridges and rock outcrops at the shelf break and on the upper slope are often heavily encrusted with gorgonians. Other coral taxa observed in these areas include colonial stony corals (e.g., *O. varicosa*, *Madracis myriaster*, and *Madrepora oculata*), black corals, and soft corals. *Oculina* bioherms (also referred to as reefs or mounds) occur extensively along the shelf break off central Florida. These bioherms function as habitat for other coral taxa including gorgonians, soft corals, black corals, and stony cup corals. *O. varicosa* coverage may reach up to 30 to 40 percent of available hard substrate in some areas, although in other areas the density may be much less and specimens may occur as thickets, isolated colonies, and coral rubble. *L. pertusa* bioherms have been recently found in relatively shallow water (about 200 m) off northeastern Florida. Relative to other parts of the Study Area, *L. pertusa* distribution in the vicinity of Navy training areas of the Jacksonville Range Complex is exceptionally well mapped (U.S. Department of the Navy, 2009). In the Jacksonville Operating Area (OPAREA), deep-water corals are found along the continental slope between 200 and 1,000 m (Reed et al., 2006). Communities of *L. pertusa* have also been found to inhabit substrate at relatively shallow depths of 180 to 250 m off the coast of northeastern Florida in the Jacksonville Range Complex (Ross et al., 2015; U.S. Department of the Navy, 2010). The dominant structure-forming scleractinian corals on the southeastern continental slope (waters generally deeper than 200 m) are *L. pertusa* and *Enallopsammia profunda*, which may form bioherms or other types of mounds. Such structures are dominant features of the Blake Plateau from North Carolina to south Florida and the Bahamas. *Lophelia* mounds off North Carolina are apparently the northernmost bioherms in the United States. Coral occurrence in the central Blake Plateau region appears to consist mostly of smaller aggregations on coral mounds and rocky substrate. Non-structure forming octocorals, black corals, bamboo corals, soft corals, and cup corals may be relatively abundant throughout the southeast region in areas of suitable habitat. The Miami Terrace occurs off southeast Florida beginning at about 275 m depth, with a series of terraces and ridges at increasing depth (beyond 870 m). The Pourtales Terrace occurs at depths of 200 to 450 m along the southern edge of the Florida Keys reef tract and provides extensive, high relief, hard bottom habitat (Hourigan et al., 2017b). Various deep-water corals occur on these features, including *L. pertusa*, *E. profunda*, octocorals, gorgonians, black corals, and stylasterids (hydrocorals). Bioherms are rare in these areas, although a *Lophelia* mound at Pourtales Terrace represents the southernmost occurrence known in U.S. waters.

The geological complexity of the deep northern Gulf of Mexico (U.S.-Mexico border to the Florida Straits) supports a high diversity of deep-water corals (Boland et al., 2016). A total of 258 deep-water coral species have been identified in the Gulf (Etnoyer & Cairns, 2017). Substrate in the western and central portion of the Gulf generally consists of fine sand, silt, and clay, while hard bottom consists of old coral reefs, salt domes, and carbonate structures. In the eastern Gulf, the Florida platform and escarpment were primarily formed by sediment deposition and carbonate-producing organisms. Research to date indicates that mesophotic reefs (approximately 30 to 150 m depth) and deep coral habitats are widespread throughout the Gulf of Mexico, but are generally restricted to relatively rare hard substrates. Although data specific to the west Florida shelf are limited, available information suggests the extent of hard bottom habitat and the associated abundance and diversity of deep-sea corals is high. Structure-forming corals are generally found on hard substrates with moderate to high relief, including banks, mounds, carbonate structures, and artificial substrates (e.g., shipwrecks and offshore energy platforms). Various species of stony corals (e.g., *Enallopsammia*, *Lophelia*, *Oculina*, and *Madrepora* species), black corals, soft corals, gorgonians, and sea pens have been documented in suitable habitat throughout the Gulf of Mexico along the continental shelf and slope, and on the outer portion of the west Florida shelf. Hydrozoans (e.g., lace corals) have only been identified in the eastern Gulf, primarily along the shelf break and slope of the southern portion of the west Florida shelf.

Deep-water corals are likely absent from the open ocean biogeographic zone because water depth is typically greater than the depth of the aragonite saturation zone (in the case of stony corals), and because of the scarcity of planktonic food in the abyssal zone (Morris et al., 2013). An exception could be the seamounts located seaward of the Northeast U.S. Continental Shelf Large Marine Ecosystem. The results of habitat suitability modeling of seamounts located in less than 2,500 m water depth and rising at least 1,000 m off the bottom suggest the potential for deep-water corals to occur at seamounts located off the northeast U.S. continental shelf (Tittensor et al., 2009), which is consistent with the observation of corals on Mytilus Seamount in the Northeast U.S. Continental Shelf Large Marine Ecosystem (Quattrini et al., 2015).

The greatest threat to deep-water coral is physical strike and disturbance resulting from human activities. Deep corals are susceptible to physical disturbance due to the branching and fragile growth form of some species, slow growth rate (colonies can be hundreds of years old), and low reproduction and recruitment rates. For example, studies of the of the black coral *Leiopathes glaberrima* in the northern Gulf of Mexico suggest that bathymetry and water circulation patterns could limit larval dispersal and recovery in the event of a large disturbance (Cardona et al., 2016). Fishing activities, particularly trawling, are the primary threats to deep corals (Boland et al., 2016; Hourigan et al., 2017b; Packer et al., 2017; Rooper et al., 2017; Rooper et al., 2016; Yoklavich et al., 2017). It has been estimated that only about 10 percent of ivory tree coral habitat remains intact off Florida's eastern coast, presumably due mostly to trawling (Koenig et al., 2005). Marine debris is also a potential threat. For example, during one study, a fishing trap, fishing line, balloon remnants, and ribbon was observed either lying on or wrapped around deep-sea corals located off the northeastern United States (Quattrini et al., 2015). Other potential human-caused threats to deep-water corals include hydrocarbon exploration and extraction, cable and pipeline installation, and other bottom-disturbing activities (Boland et al., 2016; Hourigan et al., 2017b; Packer et al., 2017). Natural threats consist of sedimentation and bioerosion of the substrate.

3.4.2.3.4 Flatworms (Phylum Platyhelminthes)

Flatworms include between 12,000 and 20,000 marine species worldwide (World Register of Marine Species Editorial Board, 2015) and are the simplest form of marine worm (Castro & Huber, 2000a). The largest single group of flatworms are parasites commonly found in fishes, seabirds, and marine mammals (Castro & Huber, 2000a; University of California Berkeley, 2010e). The life history of parasitic flatworms plays a role in the regulation of populations of the marine vertebrates they inhabit. Ingestion by the host organism is the primary dispersal method for parasitic flatworms. Parasitic forms are not typically found in the water column outside of a host organism. The remaining groups are non-parasitic carnivores, living without a host. A large number of flatworm species from numerous families are found in various habitats throughout the Study Area. Several species of wrasses and other reef fish prey on flatworms (Castro & Huber, 2000a, 2000b).

3.4.2.3.5 Ribbon Worms (Phylum Nemertea)

Ribbon worms include over 1,300 marine species worldwide (World Register of Marine Species Editorial Board, 2015). Ribbon worms, with their distinct gut and mouth parts, are more complex than flatworms (Castro & Huber, 2000a). A unique feature of ribbon worms is the extendable proboscis (an elongated, tubular mouth part), which can be ejected to capture prey, to aid in movement, or for defense (Brusca & Brusca, 2003). Most ribbon worms are active, bottom-dwelling predators of small invertebrates such as annelid worms and crustaceans (Brusca & Brusca, 2003; Castro & Huber, 2000b). Some are scavengers or symbiotic (parasites or commensals). Some ribbon worms are pelagic, with approximately 100 pelagic species identified from all oceans (Roe & Norenburg, 1999). Pelagic species generally drift or slowly swim by undulating the body. Ribbon worms exhibit a variety of reproductive strategies, including direct development with juveniles hatching from egg cases and indirect development from planktonic larvae (Brusca & Brusca, 2003). In addition, many species are capable of asexual budding or regeneration from body fragments. Ribbon worms have a relatively small number of predators, including some birds, fishes, crabs, molluscs, squid, and other ribbon worms (McDermott, 2001). Ribbon worms are found throughout the Study Area. They occur in most marine environments, although usually in low abundances. They occur in embayments; soft, intermediate, and rocky shores and subtidal habitats of coastal waters; and deep-sea habitats. Some are associated with biotic habitats such as mussel clumps, coral reefs, kelp holdfasts, seagrass beds, and worm burrows (Thiel & Kruse, 2001). Approximately 50 species of ribbon worms are known along the Atlantic coast of North America (Encyclopedia of Life, 2017), and 24 species are known from Florida and the Virgin Islands (Aguilar, 2008; Correa, 1961). Approximately 40 species of nemerteans occur in the Gulf of Mexico (Norenburg, 2009).

3.4.2.3.6 Round Worms (Phylum Nematoda)

Round worms include over 7,000 marine species (World Register of Marine Species Editorial Board, 2015). Round worms are small and cylindrical, abundant in sediment habitats such as soft to intermediate shores and soft to intermediate bottoms, and also found in host organisms as parasites (Castro & Huber, 2000a). Round worms are some of the most widespread marine invertebrates, with population densities of up to 1 million or more organisms per square meter of sediment (Levinton, 2009). This group has a variety of food preferences, including algae, small invertebrates, annelid worms, and organic material from sediment. Like parasitic flatworms, parasitic nematodes play a role in regulating populations of other marine organisms by causing illness or mortality. Species in the family Anisakidae infect marine fish, and may cause illness in humans if fish are consumed raw without proper precautions (Castro & Huber, 2000a). Round worms are found throughout the Study Area.

3.4.2.3.7 Segmented Worms (Phylum Annelida)

Segmented worms include approximately 14,000 marine species worldwide in the phylum Annelida, although the number of potentially identified marine species is nearly 25,000 (World Register of Marine Species Editorial Board, 2015). Most marine annelids are in the class Polychaeta. Polychaetes are the most complex group of marine worms, with a well-developed respiratory and gastrointestinal system (Castro & Huber, 2000a). Different species of segmented worms may be highly mobile or burrow in the bottom (soft to intermediate shore or bottom habitats) (Castro & Huber, 2000b). Polychaete worms exhibit a variety of life styles and feeding strategies, and may be predators, scavengers, deposit-feeders, filter-feeders, or suspension feeders (Jumars et al., 2015). The variety of feeding strategies and close connection to the bottom make annelids an integral part of the marine food web (Levinton, 2009). Burrowing and agitating the sediment increases the oxygen content of bottom sediments and makes important buried nutrients available to other organisms. This allows bacteria and other organisms, which are also an important part of the food web, to flourish on the bottom. Benthic polychaetes also vary in their mobility, including sessile attached or tube-dwelling worms, sediment burrowing worms, and mobile surface or subsurface worms. Some polychaetes are commensal or parasitic. Many polychaetes have planktonic larvae.

Polychaetes are found throughout the Study Area inhabiting rocky, sandy, and muddy areas of the bottom, vegetated habitats, and artificial substrates. Some are associated with biotic habitats such as mussel clumps, coral reefs, and worm burrows. Some species of worms build rigid (e.g., *Diopatra* spp.) or sand-encrusted (*Phragmatapoma* spp.) tubes, and aggregations of these tubes form a structural habitat. Giant tube worms (*Riftia pachyptila*) are chemosynthetic (using a primary production process without sunlight) reef-forming worms living on hydrothermal vents of the abyssal oceans. Their distribution is poorly known in the Study Area, although hydrothermal vents are more likely to occur in association with seamounts and the Mid-Atlantic Ridge.

The reef-building tube worm (*Phragmatopoma caudata*, synonymous with *P. lapidosa*) constructs shallow-water worm reefs in some portions of the Study Area (Read & Fauchald, 2012). Large pseudocolonies of worms (formed from large numbers of individual larvae that settle in close proximity and undergo fusion to form complex habitats) develop relatively smooth mounds up to 2 m high (Zale & Merrifield, 1989). In the Study Area, the species is particularly common in the Southeastern U.S. Continental Shelf Large Marine Ecosystem along Florida's east coast, at depths up to 2 m; however, colonies are found infrequently to depths of 100 m in areas with strong currents (South Atlantic Fishery Management Council, 1998; Zale & Merrifield, 1989).

3.4.2.3.8 Bryozoans (Phylum Bryozoa)

Bryozoans include approximately 6,000 marine species worldwide (World Register of Marine Species Editorial Board, 2015). They are small box-like, colony-forming animals that make up the "lace corals." Colonies can be encrusting, branching, or free-living. Bryozoans may form habitat similar in complexity to sponges (Buhl-Mortensen et al., 2010). Bryozoans attach to a variety of surfaces, including intermediate and hard bottom, artificial structures, and algae, and feed on particles suspended in the water (Hoover, 1998b; Pearse et al., 1987; University of California Berkeley, 2010a). Bryozoans are of economic importance for bioprospecting (the search for organisms for potential commercial use in pharmaceuticals). As common biofouling organisms, bryozoans also interfere with boat operations and clog industrial water intakes and conduits (Hoover, 1998b; Western Pacific Regional Fishery Management Council, 2001). Bryozoans occur throughout the Study Area but are not expected at depths beyond the continental slope (Ryland & Hayward, 1991). Habitat-forming species are most common on temperate continental shelves with relatively strong currents (Wood et al., 2012).

3.4.2.3.9 Squid, Bivalves, Sea Snails, Chitons (Phylum Mollusca)

The phylum Mollusca includes approximately 45,000 marine species worldwide (World Register of Marine Species Editorial Board, 2015). These organisms occur throughout the Study Area, including inshore waters and open ocean areas, at all depths. Sea snails and slugs (gastropods), clams and mussels (bivalves), chitons (polyplacophorans), and octopus and squid (cephalopods) are examples of common molluscs in the Study Area. Snails and slugs occur in a variety of soft, intermediate, hard, and biogenic habitats. Chitons are typically found on hard bottom and artificial structures from the intertidal to littoral zone but may also be found in deeper water and on substrates such as aquatic plants. Many molluscs possess a muscular organ called a foot, which is used for mobility. Many molluscs also secrete an external shell (Castro & Huber, 2000a), although some molluscs have an internal shell or no shell at all (National Oceanic and Atmospheric Administration, 2015). Sea snails and slugs eat fleshy algae and a variety of invertebrates, including hydroids, sponges, sea urchins, worms, other snails, and small crustaceans, as well as detritus (Castro & Huber, 2000a; Colin & Arneson, 1995a; Hoover, 1998c). Clams, mussels, and other bivalves are filter feeders, ingesting suspended food particles (e.g., phytoplankton, detritus) (Castro & Huber, 2000a). Chitons, sea snails, and slugs use rasping tongues, known as radula, to scrape food (e.g., algae) off rocks or other hard surfaces (Castro & Huber, 2000b; Colin & Arneson, 1995a). Squid and octopus are active swimmers at all depths and use a beak to prey on a variety of organisms including fish, shrimp, and other invertebrates (Castro & Huber, 2000a; Hoover, 1998c; Western Pacific Regional Fishery Management Council, 2001). Octopuses mostly prey on fish, shrimp, eels, and crabs (Wood & Day, 2005).

Important commercial, ecological, and recreational species of molluscs in the Study Area include: Atlantic scallop (*Placopecten megallanicus*), Atlantic surfclam (*Spisula solidissima*), ocean quahog (*Arctica islandica*), and several squid species (Mid-Atlantic Fishery Management Council, 2016; New England Fishery Management Council, 2013; Voss & Brakoniecki, 1985). Some mollusc species, principally bivalves, are habitat-forming organisms, forming sedentary invertebrate beds and biotic reefs. Examples include mussels of the genus *Mytilus*, found in intertidal areas, and the genus *Bathymodiolus*, which occur at deep-sea hydrothermal vents. Oysters in general, and principally the eastern oyster (*Crassostrea virginica*), may form extensive reefs, or beds, in estuarine waters of the Atlantic Ocean (including inshore waters) and Gulf of Mexico. Oyster reefs are highly productive habitats in inter-tidal or shallow subtidal ecosystems, providing many of the same habitat values as coral reefs.

3.4.2.3.10 Shrimp, Crab, Lobster, Barnacles, Copepods (Phylum Arthropoda)

Shrimp, crabs, lobsters, barnacles, and copepods are animals with an exoskeleton, which is a skeleton on the outside of the body (Castro & Huber, 2000a), and are classified as crustaceans in the Phylum Arthropoda. The exoskeletons are made of a polymer called chitin, similar to cellulose in plants, to which the animals add other compounds to achieve flexibility or hardness. There are over 57,000 marine arthropod species, with about 53,000 of these belonging to the subphylum Crustacea (World Register of Marine Species Editorial Board, 2015). These organisms occur throughout the Study Area at all depths. Crustaceans may be carnivores, omnivores, predators, or scavengers, preying on molluscs (primarily gastropods), other crustaceans, echinoderms, small fishes, algae, and seagrass (Waikiki Aquarium, 2009a, 2009b, 2009c; Western Pacific Regional Fishery Management Council, 2009). Barnacles and some copepods are filter feeders, extracting algae and small organisms from the water (Levinton, 2009). Copepods may also be parasitic, affecting most phyla of marine animals (Walter & Boxshall, 2017). As a group, arthropods occur in a wide variety of habitats. Shrimp, crabs, lobsters, and copepods may be associated with soft to hard substrates, artificial structures, and biogenic habitats. Barnacles inhabit hard and artificial substrates.

Important commercial, ecological, and recreational species of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico include various crab species (e.g., red crab [*Chaceon quinquedens*] and golden crab [*Chaceon fenneri*]), shrimp species (e.g., white shrimp [*Litopenaeus setiferus*] and royal red shrimp [*Pleoticus robustus*], and spiny lobster (*Panulirus argus*) (Gulf of Mexico Fishery Management Council, 2015; New England Fishery Management Council, 2010; South Atlantic Fishery Management Council, 2016). Eggs of the horseshoe crab (*Limulus polyphemus*) are a particularly important food source for some migratory birds at spring stopover sites along the northeastern U.S. coast (U.S. Fish and Wildlife Service, 2011). The American lobster is a commercially and recreationally important crustacean that has increased dramatically in population due, in part, to successful fishery management (National Marine Fisheries Service, 2012b).

3.4.2.3.11 Sea Stars, Sea Urchins, Sea Cucumbers (Phylum Echinodermata)

Organisms in this phylum include over 7,000 marine species, such as sea stars, sea urchins, and sea cucumbers (World Register of Marine Species Editorial Board, 2015). Asteroids (e.g., sea stars), echinoids (e.g., sea urchins), holothuroids (e.g., sea cucumbers), ophiuroids (e.g., brittle stars and basket stars), and crinoids (e.g., feather stars and sea lilies) are symmetrical around the center axis of the body (Mah & Blake, 2012). Echinoderms occur at all depth ranges from the intertidal zone to the abyssal zone and are almost exclusively benthic, potentially found on all substrates and structures. Most echinoderms have separate sexes, but a few species of sea stars, sea cucumbers, and brittle stars have both male and female reproductive structures. Many species have external fertilization, releasing gametes into the water to produce planktonic larvae, but some brood their eggs and release free-swimming larvae (Mah & Blake, 2012; McMurray et al., 2012). Many echinoderms are either scavengers or predators on sessile organisms such as algae, stony corals, sponges, clams, and oysters. Some species, however, filter food particles from sand, mud, or water (Hoover, 1998a). Predators of echinoderms include a variety of fish species (e.g., triggerfish, eels, rays, sharks), crabs, shrimps, octopuses, birds, and other echinoderms (sea stars).

Echinoderms are found throughout the Study Area. An important commercial echinoderm species in the Northeast U.S. Continental Shelf Large Marine Ecosystem is the green sea urchin (*Strongylocentrotus drobachiensis*) (Maine Department of Marine Resources, 2010), although this species is not federally managed.

3.4.3 Environmental Consequences

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

- **Acoustics** (sonar and other transducers; air guns; pile driving; vessel noise; weapons noise)
- **Explosives** (explosions in water)
- **Energy** (in-water electromagnetic devices; high-energy lasers)
- **Physical disturbance and strikes** (vessels and in-water devices; military expended materials; seafloor devices; pile driving)
- **Entanglement** (wires and cables; decelerators/parachutes; biodegradable polymers)
- **Ingestion** (military expended materials - munitions; military expended materials other than munitions)

- **Secondary stressors** (impacts to habitat; impacts to prey availability)

The analysis includes consideration of the mitigation that the Navy will implement to avoid potential impacts on invertebrates from explosives, and physical disturbance and strikes.

3.4.3.1 Acoustic Stressors

Assessing whether sounds may disturb or injure an animal involves understanding the characteristics of the acoustic sources, the animals that may be near the sound, and the effects that sound may have on the physiology and behavior of those animals. Marine invertebrates are likely only sensitive to water particle motion caused by nearby low-frequency sources, and likely do not sense distant or mid- and high-frequency sounds (Section 3.4.2.1.3, Sound Sensing and Production). Compared to some other taxa of marine animals (e.g., fishes, marine mammals), little information is available on the potential impacts on marine invertebrates from exposure to sonar and other sound-producing activities (Hawkins et al., 2015). Historically, many studies focused on squid or crustaceans and the consequences of exposures to broadband impulsive air guns typically used for oil and gas exploration. More recent investigations have included additional taxa (e.g., molluscs) and sources, although extensive information is not available for all potential stressors and impact categories. The following Background sections discuss the currently available information on acoustic effects to marine invertebrates. These effects range from physical injury to behavioral or stress response. Aspects of acoustic stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

3.4.3.1.1 Background

A summary of available information related to each type of effect is presented in the following sections. Some researchers discuss effects in terms of the acoustic near field and far field. The near field is an area near a sound source where considerable interference between sound waves emerging from different parts of the source is present. Amplitude may vary widely at different points within this acoustically complex zone, and sound pressure and particle velocity are generally out of phase. The far field is the distance beyond which sound pressure and particle velocity are in phase, all sound waves appear to originate from a single point, and pressure levels decrease predictably with distance. The boundary between the near and far field is frequency-dependent, with the near field extending farther at lower frequencies. It has been estimated that the near field for a sound of 500 Hz (intensity not specified) would extend about 3 m from the source (Myrberg, 2001).

3.4.3.1.1.1 Injury

Injury refers to the direct effects on the tissues or organs of an animal due to exposure to pressure waves or particle motion. Available information on injury to invertebrates resulting from acoustic sources pertains mostly to damage to the statocyst, an organ sensitive to water particle motion and responsible for balance and orientation in some invertebrates. A few studies have also investigated effects to appendages and other organs, and one study investigated zooplankton mortality in response to air gun firing.

Researchers have investigated the effects of noise on American lobsters exposed to air gun firings in an aquarium and in the field (Payne et al., 2007). Lobsters in the aquarium were placed about 3.5 m from the air guns and exposed to sound levels of about 200 dB (peak-to-peak). Caged lobsters in the field were located 2 m from the air guns and exposed to higher-intensity sound levels (about 230 dB peak-to-peak). No physical damage to appendages and no effects on balance or orientation (indicating no damage to statocysts) were observed in any lobsters. No visible evidence of damage to hepatopancreata (digestive glands) or ovaries were found. Caged snow crabs (*Chionoecetes opilio*) were exposed to repeated air gun firings in the field (Christian et al., 2003). Crabs exposed to a single air gun were placed at depths of 2 to 15 m, while crabs exposed to air gun arrays were placed at depths of 4 to 170 m. Air guns were fired during multiple sessions, with each session consisting of a firing every 10 seconds for 33 minutes. Peak received levels were up to 207 dB re 1 µPa and 187 dB referenced to 1 squared micropascal (dB re 1 μPa^2) (single gun), and 237 dB re 1 µPa and 175 dB re 1 μPa^2 (array). Post-experimental examination showed no physical damage to statocysts, hepatopancreata, heart muscle or surrounding tissue, carapace, or appendages. As a comparison, air guns operated at full capacity during Navy activities would produce a SPL of approximately 206 dB re 1 µPa rms and a sound exposure level (SEL) of 185 to 196 dB re 1 μPa^2 per second (dB re 1 μPa^2-s) at a distance 1 m from the air gun. Air guns are also operated at less than full capacity, resulting in reduced sound levels.

In three instances, seismic air gun use has been hypothesized as the cause of giant squid strandings. This was based on the proximity in time and space of the squid and operating seismic vessels and, in two of the events, to physical injuries considered consistent with exposure to impulsive acoustic waves (Guerra et al., 2004; Guerra & Gonzales, 2006; Leite et al., 2016). However, because the animals were not observed at the time of potential impact, the cause(s) of the injuries and strandings cannot be determined conclusively.

Zooplankton abundance and mortality was investigated in the context of exposure to air gun firings in an open ocean environment (McCauley et al., 2017). Net tows and sonar surveys were conducted after transects involving air gun firings were completed. The results indicated decreased zooplankton abundance and increased mortality as a result of exposure. The most abundant organisms (copepods and cladocerans [water fleas]) showed a 50 percent decrease in abundance at distances of about 500 to 700 m from the source. Received noise level at this distance was about 156 dB re 1 μPa^2 per 1 second (dB re 1 μPa^2 s^{-1}) SEL and 183 dB re 1 µPa peak-to-peak. There was no effect on the abundance of these specific taxa at distances of about 1 km from the source (153 dB re 1 μPa^2 s^{-1} SEL and 178 dB re 1 µPa peak-to-peak). However, an overall decrease in zooplankton abundance was reported at distances to about 1.2 km from the source. The authors speculate that the effects could have been caused by damage to external sensory hairs on the organisms.

Physiological studies of wild captured cephalopods found progressive damage to statocysts in squid and octopus species after exposure to 2 hours of low-frequency (50 to 400 Hz) sweeps (100 percent duty cycle) at SPL of 157 to 175 dB re 1 µPa (André et al., 2011; Sole et al., 2013). It is noted that the animals were in the near field (distance was not specified in the report, but animals were likely within a few to several feet of the sound source based on the experiment description) where there is significant particle motion. In a similar experiment designed to control for possible confounding effects of experimental tank walls, common cuttlefish (*Sepia officinalis*) were exposed to 2 hours of low-frequency sweeps (100 to 400 Hz; 100 percent duty cycle with a 1-second sweep period) in an offshore environment (Sole et al., 2017). Sounds were produced by a transducer located near the surface, and caged experimental animals were placed at depths between 7 and 17 m. Received sound levels ranged from 139 to 142 dB re 1 μPa^2. Maximum particle motion of 0.7 meter per squared second was recorded at the cage nearest the transducer (7.1 m between source and cage). Progressive damage to sensory hair cells of the statocysts were found immediately after and 48 hours after sound exposure, with the severity of effects being proportional to distance from the transducer. The authors suggest that whole-body vibrations resulting from particle motion were transmitted to the statocysts, causing damage to the structures.

Statocyst damage was also found in captive individuals of two jellyfish species (Mediterranean jellyfish [*Cotylorhiza tuberculata*] and barrel jellyfish [*Rhizostoma pulmo*]) under the same exposure parameters (50 to 400 Hz sweeps; 2 hour exposure time; 100 percent duty cycle with a 1-second sweep period; approximately 157 to 175 dB re 1 µPa received SPL) (Sole et al., 2016). In the context of overall invertebrate population numbers, most individuals exposed to acoustic stressors would be in the far field where particle motion would not occur and, therefore, the types of damage described above would not be expected. In addition, exposure duration would be substantially less than 2 hours.

This limited information suggests that the potential for statocyst damage may differ according to the type of sound (impulsive or continuous) or among invertebrate taxa (e.g., crustaceans and cephalopods). Therefore, a definitive conclusion regarding potential impacts to invertebrates in general is unsupported. Although invertebrate occurrence varies based on location, depth, season, and time of day (for example, the rising of the deep scattering layer, which consists of numerous invertebrate taxa), individuals could be present in the vicinity of impulsive or non-impulsive sounds produced by Navy activities. Estimation of invertebrate abundance at any particular location would generally not be feasible, but there is a general pattern of higher abundances in relatively productive estuarine and nearshore waters compared to abundances in offshore portions of the Study Area. The number of individuals affected would be influenced by sound sensing capabilities. As discussed in Section 3.4.2.1.3 (Sound Sensing and Production), invertebrate acoustic sensing is probably limited to the particle motion component of sound. Water particle motion is most detectable near a sound source and at lower frequencies, which likely limits the range at which invertebrates can detect sound.

3.4.3.1.1.2 Physiological Stress

A stress response consists of one or more physiological changes (e.g., production of certain hormones) that help an organism cope with a stressor. However, if the magnitude or duration of the stress response is too great or too prolonged, there can be negative consequences to the organism. Physiological stress is typically evaluated by measuring the levels of relevant biochemicals in the subject organisms.

The results of two investigations of physiological stress in adult invertebrates caused by impulsive noise varied by species. Some biochemical stress markers and changes in osmoregulation were observed in American lobsters exposed to air gun firings at distances of approximately 2 to 4 m from the source (Payne et al., 2007). Increased deposits of carbohydrates, suggesting a possible stress response, were noted in digestive gland cells 4 months after exposure. Conversely, repeated air gun exposures caused no changes in biochemical stress markers in snow crabs located from 2 to 170 m from the source (Christian et al., 2003).

Several investigations of physiological reactions of captive adult invertebrates exposed to boat noise playback and other continuous noise have been conducted. Continuous exposure to boat noise playback resulted in changes to some biochemical levels indicating stress in common prawns (*Palaemon serratus*) (30-minute exposure to sound levels of 100 to 140 dB re 1 µPa rms) and European spiny lobsters (30-minute exposure to sound levels up to 125 dB re 1µPa rms) (Celi et al., 2015; Filiciotto et al., 2014; Filiciotto et al., 2016). Increased oxygen consumption, potentially indicating stress, was found in shore crabs exposed to ship-noise playback of 148 to 155 dB re 1 µPa for 15 minutes (Wale et al., 2013b). Red swamp crayfish (*Procambarus clarkii*) exposed to 30-minute continuous acoustic sweeps (frequency range of 0.1 to 25 kHz, peak amplitude of 148 dB rms at 12 kHz) showed changes in some biochemical levels indicating stress (Celi et al., 2013). Captive sand shrimp (*Crangon crangon*) exposed to low-frequency noise (30 to 40 dB above ambient) continuously for 3 months demonstrated decreases in growth rate and reproductive rate (Lagardère, 1982). Mediterranean mussels (*Mytilus galloprovincialis*) exposed to 30-minute continuous acoustic sweeps (frequency range of 0.1 to 60 kHz, maximum SPL of 150 dB rms re 1 µPa), although exhibiting no behavioral changes at any tested frequency, showed statistically significant increases in some biochemical stress indicators (e.g., glucose and heat shock protein) in the low-frequency exposure category (0.1 to 5 kHz) (Vazzana et al., 2016). Changes in glucose levels were found in blue crabs (*Callinectes sapidus*) exposed to low-frequency sound (broadband noise with a significant component of 60 Hz at approximately 170 dB re 1 µPa SPL) and mid-frequency pulsed tones and chirps (1.7 to 4 kHz at approximately 180 dB re 1 µPa SPL) (Dossot et al., 2017).

In addition to experiments on adult invertebrates, some studies have investigated the effects of impulsive and non-impulsive noise (air guns, boat noise, turbine noise) on invertebrate eggs and larvae. Data on similar effects resulting from sonar are currently unavailable. Developmental delays and body malformations were reported in New Zealand scallop (*Pecten novaezelandiae*) larvae exposed to seismic air gun playbacks at frequencies of 20 Hz to 22 kHz with SPL of 160 to 164 dB re 1 µPa (Aguilar de Soto et al., 2013). Although uncertain, the authors suggested physiological stress as the cause of the effects. Larvae in the relatively small (2 m diameter) experimental tank were considered close enough to the acoustic source to experience particle motion, which would be unlikely at the same pressure levels in the far field. Playbacks occurred once every 3 seconds and the larvae were periodically examined over the course of 90 hours. Snow crab (*Chionoecetes opilio*) eggs located in 2 m water depth and exposed to repeated firings of a seismic air gun (peak received SPL was 201 dB re 1 µPa) had slightly increased mortality and apparent delayed development (Christian et al., 2003). However, Dungeness crab (*Metacarcinus magister*) zoeae were not affected by repeated exposures to an air gun array (maximum distance of about 62 feet [ft.] slant distance) (Pearson et al., 1994), and exposure of southern rock lobster (*Jasus edwardsii*) eggs to air gun SELs of up to 182 dB re 1 μPa^2-s did not result in embryonic developmental effects (Day et al., 2016). An investigation of the effects of boat noise playback on the sea hare (*Stylocheilus striatus*) found reduced embryo development and increased larvae mortality, but no effect on the rate of embryo development (Nedelec et al., 2014). Specimens were exposed to boat-noise playback for 45 seconds every 5 minutes over a 12-hour period. Continuous playback of simulated underwater tidal and wind turbine sounds resulted in delayed metamorphosis in estuarine crab larvae (*Austrohelice crassa* and *Hemigrapsus crenulatus*) that were observed for up to about 200 hours (Pine et al., 2016).

Overall, the results of these studies indicate the potential for physiological effects in some, but not all, adult invertebrates exposed to air guns near the source (about 2 to 4 m) and to boat and other continuous noise for durations of 15 to 30 minutes or longer. Larvae and egg development effects were reported for impulsive (distance from source of about 2 m) and non-impulsive noise exposures of extended duration (intermittently or continuously for several to many hours) and for air gun playback and field exposure, although air gun noise had no effect in one study. In general, exposure to continuous noise such as vessel operation during Navy training or testing events would occur over a shorter duration and sound sources would be more distant than those associated with most of the studies. Adverse effects resulting from short exposure times have not been shown experimentally. A range to effects was not systematically investigated for air gun use. Experiments using playback of air gun and boat noise were conducted in relatively small tanks where particle motion, which decreases rapidly with distance, could have been significant. Marine invertebrate egg and larval abundances are high relative to the number of adults, and eggs and larvae are typically subject to high natural mortality rates. These factors decrease the likelihood of population-level effects resulting from impacts to eggs and larvae from physiological stress associated with Navy training and testing events.

3.4.3.1.1.3 Masking

Masking occurs when one sound interferes with the detection or recognition of another sound. Masking can limit the distance over which an organism can communicate or detect biologically relevant sounds. Masking can also potentially lead to behavioral changes.

Little is known about how marine invertebrates use sound in their environment. Some studies show that crab, lobster, oyster, and coral larvae and post-larvae may use nearby reef sounds when in their settlement phase. Orientation and movement toward reef sounds was found in larvae located at 60 to 80 m from a sound source in open water and in experimental tanks (distance from the sound source was about 150 cm in one laboratory study) (Radford et al., 2007; Stanley et al., 2010; Vermeij et al., 2010). The component of reef sound used is generally unknown, but an investigation found that low-frequency sounds (200 to 1,000 Hz) produced by fish at dawn and dusk on a coral reef were the most likely sounds to be detectable a short distance from the reef (Foster et al., 2012; Kaplan & Mooney, 2016). Similarly, lobed star coral larvae were found to have increased settlement on reef areas with elevated sound levels, particularly in the frequency range of 25 to 1,000 Hz (Lillis et al., 2016). Mountainous star coral larvae in their settlement phase were found to orient toward playbacks of reef sounds in an experimental setup, where received sound levels were about 145 to 149 dB re 1 µPa and particle velocity was about 9×10^{-8} meters per second (Vermeij et al., 2010). Playback speakers were located approximately 1 to 2 m from the larvae, although the authors suggest marine invertebrates may also use sound to communicate and avoid predators (Popper et al., 2001). Crabs (*Panopeus* species) exposed to playback of predatory fish vocalizations reduced foraging activity, presumably to avoid predation risk (Hughes et al., 2014). The authors suggest that, due to lack of sensitivity to sound pressure, crabs are most likely to detect fish sounds when the fish are nearby. Anthropogenic sounds could mask important acoustic cues such as detection of settlement cues or predators, and potentially affect larval settlement patterns or survivability in highly modified acoustic environments (Simpson et al., 2011). Low-frequency sounds could interfere with perception of low-frequency rasps or rumbles among crustaceans, particularly when conspecific sounds are produced at the far end of the hearing radius. Navy activities occurring relatively far from shore would produce transient sounds potentially resulting in only intermittent, short-term masking, and would be unlikely to impact the same individuals within a short time. Training and testing activities would generally not occur at known reef sites within the probable reef detection range of larvae. Impacts could be more likely in locations where anthropogenic noise occurs frequently within the perceptive range of invertebrates (e.g., pierside locations in estuaries). There are likely many other non-Navy noise sources present in such areas, and potential impacts on invertebrates would be associated with all anthropogenic sources.

3.4.3.1.1.4 Behavioral Reactions

Behavioral reactions refer to alterations of natural behaviors due to exposure to sound. Most investigations involving invertebrate behavioral reactions have been conducted in relation to air gun use, pile driving, and vessel noise. Studies of air gun impacts on marine invertebrates (crustaceans and cephalopods) have typically been conducted with equipment used for seismic exploration, and the limited results suggest responses may vary among taxa. Snow crabs placed 48 m below a seismic air gun array did not react behaviorally to repeated firings (peak received SPL was 201 dB re 1 µPa) (Christian et al., 2003). Studies of commercial catch of rock lobsters (*Panulirus cygnus*) and multiple shrimp species in the vicinity of seismic prospecting showed no long-term adverse effects to catch yields, implying no detectable long-term impacts on abundance from intermittent anthropogenic sound exposure over long periods (Andriguetto-Filho et al., 2005; Parry & Gason, 2006). Conversely, squid have exhibited various behavioral reactions when exposed to impulsive noise such as air gun firing (McCauley et al., 2000a; McCauley et al., 2000b). Some squid showed strong startle responses, including inking, when exposed to the first shot of broadband sound from a nearby seismic air gun (received SEL of 174 dB re 1 µPa rms). Strong startle response was not seen when sounds were gradually increased, but the squid exhibited alarm responses at levels above 156 dB re 1 µPa rms (McCauley et al., 2000a; McCauley et al., 2000b). Southern reef squids (*Sepioteuthis australis*) exposed to air gun noise displayed alarm responses at levels above 147 dB re 1 μPa^2-s (Fewtrell & McCauley, 2012).

Pile driving produces sound pressure that moves through the water column and into the substrate, which may therefore affect both pelagic and benthic invertebrates. Impact pile driving produces a repetitive impulsive sound, while vibratory pile extraction produces a nearly continuous sound at a lower source level. Although few investigations have been conducted regarding impacts to invertebrates resulting from impact pile driving and extraction, the effects are likely similar to those resulting from other impulsive and vibrational (e.g., drilling) sources. When an underwater sound encounters the substrate, particle motion can be generated, resulting in vibration. Invertebrates may detect and respond to such vibrations. Playback of impact pile driving sound (137 to 152 dB re 1 µPa peak to peak) in the water column near chorusing snapping shrimp resulted in an increase in the snap number and amplitude (Spiga, 2016). When exposed to playback of broadband impulsive pile driving sound of 150 dB SEL, Japanese carpet shell clams (*Ruditapes philippinarum*) exhibited reduced activity and valve closing, while Norway lobsters (*Nephrops norvegicus*) repressed burying, bioirrigation, and locomotion activity (Solan et al., 2016). Brittlestars (*Amphiura filiformis*) included in the experiment exhibited no overall statistically detectable behavioral changes, although the authors note that a number of individuals exhibited changes in the amount of sediment reworking activity. Pacific oysters (*Magallana gigas*) exposed to 3-minute pure tones responded behaviorally (shell closure) to low-frequency sounds, primarily in the range of 10 to 200 Hz (Charifi et al., 2017). The oysters were most sensitive to sounds of 10 to 80 Hz at 122 dB rms re 1 µPa, with particle acceleration of 0.02 meter per squared second. Invertebrates exposed to vibrations of 5 to 410 Hz (which is a proxy for the effects of vibratory pile removal) at various particle acceleration amplitudes in the substrate of a holding tank for 8-second intervals exhibited behavioral reactions ranging from valve closure (common mussel [*Mytilus edulis*]) to antennae sweeping, changes in locomotion, and exiting the shell (common hermit crab [*Pagurus bernhardus*]) (Roberts et al., 2015; Roberts et al., 2016a). Sensitivity was greatest at 10 Hz and at particle acceleration of 0.1 meter per squared second. The authors analyzed data on substrate acceleration produced by pile driving in a river and found levels that would be detectable by the hermit crabs at 17 and 34 m from the source. Measurements were not available for other distances or in marine environments. Similarly, underwater construction-related detonations of about 14-pound (lb.) charge weight (presumably in fresh water) resulted in substrate vibrations 297 m from the source that would likely be detected by crabs. Follow-up experiments showed that particle acceleration detection sensitivity in mussels and hermit crabs ranged from 0.06 to 0.55 meters per squared second (Roberts et al., 2016b). Subsequent semi-field experiments consisted of operating a small pile driver for 2-hour periods in an enclosed dock (90 m long by 18 m wide, water depth of 2 to 3 m, and sediment depth of 3 to 4 m). Vibration in the sediment propagated farther (up to 30 m) in shallower water than in deeper water (up to 15 m). The signal in the sediment was mostly below 100 Hz and primarily from 25 to 35 Hz. Experimental animals in the enclosed area exhibited behavioral (e.g., width of shell opening) and physiological (e.g., oxygen demand) responses as a result of exposure, although information such as distance from the pile driver and particle acceleration at specific locations was not provided.

Common prawns and European spiny lobsters exposed to 30 minutes of boat noise playback in frequencies of 200 Hz to 3 kHz (sound levels of approximately 100 to 140 dB SPL [prawns] and 75 to 125 dB SPL [lobsters]) showed behavioral responses including changes in movement velocity, and distance moved, as well as time spent inside a shelter (Filiciotto et al., 2014; Filiciotto et al., 2016). Common cuttlefish exposed to playback of underwater ferry engine noise for 3.5 minutes (maximum sound level of about 140 dB re 1 µPa SPL) changed color more frequently, swam more, and raised their tentacles more often than control specimens or individuals exposed to playback of wave sounds (Kunc et al., 2014). Shore crabs (*Carcinus maenas*) exposed to ship noise playback did not exhibit changes in the ability or time required to find food, but feeding was often suspended during the playback (Wale et al., 2013a). Japanese carpet shell clams and Norway lobsters exposed to playback of ship noise for 7 days at received levels of 135 to 140 dB re 1 µPa exhibited reactions such as reduced activity, movement, and valve closing (Solan et al., 2016). Brittlestars (*A. filiformis*) included in the study showed no overall statistically detectable behavioral changes, although individual animals were affected. Antarctic krill (*Euphausia superba*) did not respond to a research vessel approaching at 2.7 knots (source level below 150 dB re 1 µPa) (Brierley et al., 2003). Decreased activity levels were found in blue crabs exposed to low-frequency broadband sound with a significant component of 60 Hz (approximately 170 dB re 1 µPa SPL) and mid-frequency pulsed tones and chirps (1.7 to 4 kHz at approximately 180 dB re 1 µPa SPL) (Dossot et al., 2017). Exposure to low-frequency sounds resulted in more pronounced effects than exposure to mid-frequency sounds. American lobsters appeared to be less affected than crabs.

A limited number of studies have investigated behavioral reactions to non-impulsive noise other than that produced by vessels. Red swamp crayfish (*Procambarus clarkii*) exposed to 30-minute continuous acoustic sweeps (frequency range of 0.1 to 25 kHz, peak amplitude of 148 dB rms at 12 kHz) exhibited changes in social behaviors (Celi et al., 2013). Caribbean hermit crabs (*Coenobita clypeatus*) delayed reaction to an approaching visual threat when exposed to continuous noise (Chan et al., 2010a; Chan et al., 2010b). The delay potentially put them at increased risk of predation, although the studies did not address possible simultaneous distraction of predators. Razor clams (*Sinonovacula constricta*) exposed to white noise and sine waves of 500 and 1,000 Hz responded by digging at a sound level of about 100 dB re 1 µPa (presumably as a defense reaction), but did not respond to sound levels of 80 dB re 1 µPa (Peng et al., 2016). Mediterranean mussels exposed to 30-minute continuous acoustic sweeps (frequency range of 0.1 to 60 kHz, maximum SPL of 150 dB rms re 1 µPa) showed no statistically significant behavioral changes compared to control organisms (Vazzana et al., 2016).

The results of these studies indicate that at least some invertebrate taxa would respond behaviorally to various levels of sound and substrate vibration produced within their detection capability. Comprehensive investigations of the range to effects of different sound and vibration sources and levels are not available. However, sound source levels for Navy pile diving and air gun use are within the range of received levels that have caused behavioral effects in some species. The low-frequency component of vessel noise would likely be detected by some invertebrates, although the number of individuals affected would be limited to those near enough to a source to experience particle motion.

3.4.3.1.2 Impacts from Sonar and Other Transducers

Many non-impulsive sounds associated with training and testing activities are produced by sonar. Other transducers include items such as acoustic projectors and countermeasure devices. Most marine invertebrates do not have the capability to sense sound pressure; however, some are sensitive to nearby low-frequency sounds, such as could be approximated by some low-frequency sonars. As described in Section 3.4.2.1.3 (Sound Sensing and Production), invertebrate species detect sound through particle motion, which diminishes rapidly with distance from the sound source. Therefore, the distance at which they may detect a sound is probably limited. Most activities using sonar or other transducers would be conducted in deep-water, offshore portions of the Study Area and are not likely to affect most benthic invertebrate species (including ESA-listed coral species), although invertebrates in the water column could be affected. However, portions of the range complexes and testing ranges overlap nearshore waters of the continental shelf, and it is possible that sonar and other transducers could be used and affect benthic invertebrates in these areas. Sonar is also used in shallow water during pierside testing and maintenance testing.

Invertebrate species generally have their greatest sensitivity to sound below 1 to 3 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 Study Area. Studies of the effects of continuous noise such as boat noise, acoustic sweeps, and tidal/wind turbine sound (information specific to sonar use was not available) on invertebrates have found statocyst damage, elevated levels of biochemicals indicative of stress, changes in larval development, masking, and behavioral reactions under experimental conditions (see Section 3.4.3.1.1, Background). Noise exposure in the studies generally lasted from a few minutes to 30 minutes. The direct applicability of these results is uncertain because the duration of sound exposure in many of the studies is greater than that expected to occur during Navy activities, and factors such as environmental conditions (captive versus wild conditions) may affect individual responses (Celi et al., 2013). Individuals of species potentially susceptible to statocyst damage (e.g., some cephalopods) could be physically affected by nearby noise. Available research has shown statocyst damage to occur after relatively long-duration exposures (2 hours), which would be unlikely to occur to individual invertebrates due to transiting sources and potential invertebrate movement. An exception is pierside sonar testing and maintenance testing, where invertebrates (particularly sessile or slow-moving taxa such as bivalve molluscs, hydroids, and marine worms) could be exposed to sound for longer time periods compared to at-sea activities. Some studies also indicate the potential for impacts to invertebrate larval development resulting from exposure to non-impulsive noise (continuous or intermittent exposures over time periods of 12 to 200 hours) although, similar to stress effects, sonar has not been studied specifically. Masking could affect behaviors such as larvae settlement, communication, predator avoidance, and foraging in mollusc, crustacean, and coral species.

3.4.3.1.2.1 Impacts from Sonar and Other Transducers Under Alternative 1

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

Under Alternative 1, marine invertebrates would be exposed to low-, mid-, and high-frequency sonar and sound produced by other transducers during training activities. These activities could occur throughout the Study Area, including all range complexes except the Key West Range Complex, where the majority of shallow-water coral habitat is located. The locations and number of activities proposed for training under Alternative 1 are shown in Table 2.6-1 (Proposed Training Activities per Alternative) of Chapter 2 (Description of Proposed Action and Alternatives). Sounds produced during training are described in Section 3.0.3.3.1.1 (Sonar and Other Transducers).

Invertebrates would likely only sense low-frequency sonar or the low-frequency component of nearby sounds associated with other transducers. Sonar and other transducers are often operated in deep water, where impacts would be more likely for pelagic species than for benthic species. Only individuals within a short distance (potentially a few feet) of the most intense sound levels would experience impacts to sensory structures such as statocysts. Any marine invertebrate that detects low-frequency sound produced during training activities may alter its behavior (e.g., change swim speed, move away from the sound, or change the type or level of activity). Given the limited distance to which marine invertebrates are sensitive to sound, only a small number of individuals relative to overall population sizes would likely have the potential to be impacted. Because the distance over which most marine invertebrates are expected to detect any sounds is limited and because most sound sources are transient or intermittent (or both), any physiological effects, masking, or behavioral responses would be short term and brief. Without prolonged exposures to nearby sound sources, adverse impacts to individual invertebrates are not expected, and there would be no effects at the population level. Sonar and other sounds may result in brief, intermittent impacts to individual marine invertebrates and groups of marine invertebrates close to a sound source, but they are unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

Current research does not support a biologically relevant impact of sound from sonar and other transducers at the levels predicted to occur within the Key West Range Complex or Gulf of Mexico. Sound produced by sonar and other transducers is, therefore, not likely to impact ESA-listed coral species in these areas. In addition, training activities would not occur in elkhorn and staghorn critical habitat that is designated in shallow waters along southern Florida and around Puerto Rico. Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

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

Under Alternative 1, marine invertebrates could be exposed to low-, mid-, and high-frequency acoustic sources during testing activities. Testing activities using sonar and other transducers could occur throughout the Study Area, including all range complexes; at Naval Undersea Warfare Center Division, Newport Testing Range; Naval Surface Warfare Center, Panama City Division Testing Range; South Florida Ocean Measurement Facility Testing Range; and pierside at Navy ports (Little Creek, Virginia; Kings Bay, Georgia; and Port Canaveral, Florida), naval shipyards, and Navy-contractor shipyards. The locations and number of activities proposed for testing under Alternative 1 are shown in Tables 2.6-2, 2.6-3, and 2.6-4 (respectively, Naval Air Systems Command, Naval Sea Systems Command, and Office of Naval Research Proposed Testing Activities per Alternative) of Chapter 2 (Description of Proposed Action and Alternatives). Sounds produced during testing are described in Section 3.0.3.3.1.1 (Sonar and Other Transducers).

Invertebrates would likely only sense low-frequency sonar or the low-frequency component of nearby sounds associated with other transducers. Sonar and other transducers are often operated in deep water, where impacts would be more likely for pelagic species than for benthic species. Only individuals within a short distance (potentially a few feet) of the most intense sound levels would experience impacts on sensory structures such as statocysts. Any marine invertebrate that senses nearby or low-frequency sounds could react behaviorally. However, given the limited distance to which marine invertebrates are sensitive to sound, only a small number of individuals would likely be impacted. With the exception of pierside sonar testing, most sound sources are transient, and any physiological or behavioral responses or masking would be short term and brief. During pierside testing, invertebrates could be exposed to sound for longer time periods compared to at-sea testing. Pierside testing events generally occur over several hours of intermittent use. Sessile species or species with limited mobility located near pierside activities would be exposed multiple times. Species with greater mobility could potentially be exposed multiple times, depending on the time between testing events and the activity of individual animals. The limited information available suggests that sessile marine invertebrates repeatedly exposed to sound could experience physiological stress or react behaviorally (e.g., shell closing). However, recent survey work by the Virginia Institute of Marine Science suggests large populations of oysters inhabit Navy piers in the Chesapeake Bay that have persisted despite a history of sonar use in the area (Horton, 2016). In general, during use of sonar and other transducers, impacts would be more likely for sessile or limited-mobility taxa (e.g., sponges, bivalve molluscs, and echinoderms) than for mobile species (e.g., squids). Overall, given the limited distance to which marine invertebrates are sensitive to sound and the transient or intermittent nature (or both) of most sound sources, sonar and other sounds may result in brief, intermittent impacts to individual marine invertebrates and groups of marine invertebrates close to a sound source. The number of individuals affected would likely be small relative to overall population sizes. Sonar and other sounds are unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

Testing activities using sonar and other transducers are not proposed in ESA-listed elkhorn and staghorn critical habitat designated in shallow waters along southern Florida and around Puerto Rico. Pierside sonar testing at Port Canaveral would not result in sound exposure to ESA-listed corals because the northernmost distribution of these species occurs south of Port Canaveral. Sonar would be used during testing activities at the South Florida Ocean Measurement Facility Testing Range and could therefore expose corals to underwater sound. However, activities using low-frequency sonar would not be conducted within the coastal zone (3 NM from shore), and coral exposure would therefore not be expected because the distribution of shallow-water corals in the South Florida Ocean Measurement Facility Testing Range is limited to a relatively narrow band very close to shore. ESA-listed coral species may occur in deeper mesophotic waters seaward of the coastal zone, but an exposure close enough to cause particle motion and potential response from coral species also represents a hazard to safe navigation and would, therefore, be avoided. Coral larvae may be exposed to sonar and other transducers close enough to experience brief particle motion, but the available research does not support a biologically relevant response to that level of exposure. In general, sound exposure would be temporary, from primarily mobile sources, and ESA-listed corals would therefore not be subjected to prolonged sonar exposure in any portion of the Study Area. Pursuant to the ESA, the use of sonar and other transducers during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species because of the following:

- Prolonged pierside sonar testing would not intersect the distribution of ESA-listed shallow-water or mesophotic coral species in the Study Area.
- Testing of sonar and other transducers from mobile platforms in mostly deeper water (away from areas where ESA-listed shallow-water corals would most likely occur) would result in a temporary exposure only very close to the near surface sources affecting primarily pelagic invertebrates. ESA-listed coral species may occur in deeper mesophotic waters seaward of the coastal zone, but an exposure close enough to cause particle motion and potential response from coral species also represents a hazard to safe navigation and would, therefore, be avoided.

Although coral larvae may occur near the surface, brief exposure to a transient source would result in no detectable behavioral or physiological impacts, including larvae settlement.

- Corals are only known to be able to detect low-frequency sounds, meaning only low-frequency sonar would have the potential to be detected by corals. However, in the South Florida Ocean Measurement Facility Testing Range, low-frequency sonar would not be used within 3 NM of shore, and shallow-water coral exposure would therefore not be expected.

3.4.3.1.2.2 Impacts from Sonar and Other Transducers Under Alternative 2

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

Under Alternative 2, marine invertebrates would be exposed to low-, mid-, and high-frequency sonar and sound produced by other transducers during training activities. The location of training activities would be the same as those described for Alternative 1, and are shown in Table 2.6-1 (Proposed Training Activities per Alternative) of Chapter 2 (Description of Proposed Action and Alternatives). Sounds produced during training are described in Section 3.0.3.3.1.1 (Sonar and Other Transducers).

Potential impacts to invertebrates would be similar to those discussed for training activities under Alternative 1. The only difference between Alternatives 1 and 2 in sonar and other transducer use is that the number of sonar hours used would be greater under Alternative 2 (Table 3.0-2, Sonar and Transducer Sources Quantitatively Analyzed). While the types of expected impacts to any individual invertebrate or group of invertebrates capable of detecting sonar or other sounds produced during training activities would remain the same, more animals would likely be affected. In the context of overall invertebrate population sizes and vertical distribution (benthic versus pelagic) within training areas, few individuals of any species would be close enough to the most intense sound level to experience impacts to sensory structures such as statocysts. Sonar and other sounds could result in stress, masking, or behavioral effects to marine invertebrates occurring close to a sound source. These exposures would generally be short term and brief, and a small number of individuals would be affected relative to overall population sizes. Physiological or behavioral effects resulting from sonar and other sounds are unlikely to impact survival, growth, recruitment, or reproduction of invertebrate populations or subpopulations.

Current research does not support a biologically relevant impact of sound from sonar and other transducers at the levels predicted to occur within the Key West Range Complex or Gulf of Mexico. Sound produced by sonar and other transducers is, therefore, not likely to impact ESA-listed coral species in these areas. In addition, training activities would not occur in elkhorn and staghorn critical habitat that is designated in shallow waters along southern Florida and around Puerto Rico. Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

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

Under Alternative 2, marine invertebrates would be exposed to low-, mid-, and high-frequency acoustic sources during testing activities. The location of testing activities using sonar and other transducers would be the same as those described for Alternative 1 and are shown in Tables 2.6-2, 2.6-3, and 2.6-4 (respectively, Naval Air Systems Command, Naval Sea Systems Command, and Office of Naval Research Proposed Testing Activities per Alternative) of Chapter 2 (Description of Proposed Action and Alternatives). Sounds produced during testing are described in Section 3.0.3.3.1.1 (Sonar and Other Transducers).

Potential impacts to invertebrates would be similar to those discussed for testing activities under Alternative 1. The only difference between Alternatives 1 and 2 in sonar and other transducer use is that the number of sonar hours used would be greater under Alternative 2 (Table 3.0-2, Sonar and Transducer Sources Quantitatively Analyzed). The increase is associated with mid-frequency and high-frequency sonar, which is probably outside the detection capability of most marine invertebrates. Therefore, the increase in sonar and other transducer use would likely result in only a negligible increase in the number of individual invertebrates potentially affected. In the context of overall invertebrate population sizes and vertical distribution (benthic versus pelagic) within testing areas, few individuals of any species would be close enough to the most intense sound level to experience impacts to sensory structures such as statocysts. Sonar and other sounds could result in stress, masking, or behavioral effects to marine invertebrates occurring close to a sound source. These effects would generally be short term and brief, and a small number of individuals would be affected relative to overall population sizes. Physiological or behavioral effects resulting from sonar and other sounds are unlikely to impact survival, growth, recruitment, or reproduction of invertebrate populations or subpopulations. Testing activities using sonar and other transducers are not proposed in ESA-listed elkhorn and staghorn critical habitat designated in shallow waters along southern Florida and around Puerto Rico. Pierside sonar testing at Port Canaveral would not result in sound exposure to shallow-water corals. Sonar would be used during testing activities at the South Florida Ocean Measurement Facility Testing Range. However, activities using low-frequency sonar would not be conducted within the coastal zone (3 NM from shore), and coral exposure would therefore not be expected because the distribution of corals in the South Florida Ocean Measurement Facility Testing Range is limited to a relatively narrow band very close to shore. ESA-listed coral species may occur in deeper mesophotic waters seaward of the coastal zone, but an exposure close enough to cause particle motion and potential response from coral species also represents a hazard to safe navigation and would, therefore, be avoided. Coral larvae may be exposed to sonar and other transducers close enough to experience brief particle motion, but the available research does not support a biologically relevant response to that level of exposure. In general, sound exposure would be temporary, from primarily mobile sources, and ESA-listed corals would therefore not be subjected to prolonged sonar exposure in any portion of the Study Area. Pursuant to the ESA, the use of sonar and other transducers during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species because of the following:

- Prolonged pierside sonar testing would not intersect the distribution of ESA-listed shallow-water or mesophotic coral species in the Study Area.
- Testing of sonar and other transducers from mobile platforms in mostly deeper water (away from shallow areas where ESA-listed corals would most likely occur) would result in a temporary exposure only very close to the near surface sources affecting primarily pelagic invertebrates. ESA-listed coral species may occur in deeper mesophotic waters seaward of the coastal zone, but an exposure close enough to cause particle motion and potential response from coral species also represents a hazard to safe navigation and would, therefore, be avoided. Although coral larvae may occur near the surface, brief exposure to a transient source would result in no detectable behavioral or physiological impacts, including larvae settlement.
- Corals are only known to be able to detect low-frequency sounds, meaning only low-frequency sonar would have the potential to be detected by corals. However, in the South Florida Ocean Measurement Facility Testing Range, low-frequency sonar would not be used within 3 NM of shore, and shallow-water coral exposure would therefore not be expected.

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

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

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

3.4.3.1.3 Impacts from Air Guns

Air guns produce shock waves that are somewhat similar to those produced by explosives (see Section 3.4.3.2.2, Impacts from Explosives) but of lower intensity and slower rise times. An impulsive sound is generated when pressurized air is released into the surrounding water. Some studies of air gun impacts on marine invertebrates have involved the use of an array of multiple seismic air guns, although arrays are not used during Navy training and testing activities. The volume capacity of air guns used for Navy testing (60 cubic inches at full capacity) is generally within the volume range of single air guns used in seismic exploration (typically 20 to 800 cubic inches). However, seismic air guns are used in arrays with a total volume of several thousands of cubic inches, which is far more than would be associated with any Navy activities. Generated impulses would have short durations, typically a few hundred milliseconds. The root-mean-squared SPL and SEL at a distance of 1 m from the air gun would be approximately 200 to 210 dB re 1 µPa and 185 to 195 dB re 1 µPa^2-s, respectively.

The results of studies of the effects of seismic air guns on marine invertebrates, described in detail in Section 3.4.3.1 (Acoustic Stressors), suggest possible differences between taxonomic groups and life stages. Physical injury has not been reported in relatively large crustaceans (crabs, shrimp, and lobsters) exposed to seismic air guns at received levels comparable to the source level of Navy air guns operated at full capacity, but one study reported injury and mortality for zooplankton at exposures below Navy source levels. Evidence of physiological stress was not found in crabs exposed to sound levels up to 187 dB re 1 µPa^2. However, stress response was reported for lobsters located about 3.5 m from the source, where particle motion was likely detectable. While behavioral reaction to air guns has not been documented for crustaceans, squid have exhibited startle and alarm responses at various sound levels. Squid have shown startle response at received levels of 156 to 174 dB re 1 µPa rms (distance from sound source is unclear but presumed to be 30 m based on experimental description), although the reactions were less intense when ramp-up procedures (beginning with lower-intensity sound and progressing to higher levels) were used. In one study, onset of alarm response occurred at 147 dB re 1 µPa^2-s; distance from the source was not provided. Developmental effects to crab eggs and scallop larvae were found at received levels of 210 and 164 dB 1 µPa SPL (about 7 ft. from the source). Conversely, crab zoeae located 62 ft. from an air gun source showed no developmental effects. Air gun use could also result in substrate vibration, which could cause behavioral effects in nearby benthic invertebrates.

3.4.3.1.3.1 Impacts from Air Guns Under Alternative 1

Impacts from Air Guns Under Alternative 1 for Training Activities

There would be no air gun use associated with training activities. Therefore, air guns are not analyzed in this subsection.

Impacts from Air Guns Under Alternative 1 for Testing Activities

Air guns would be used in the Northeast, Gulf of Mexico, and Virginia Capes Range Complexes, the Naval Surface Warfare Center, Panama City Division and Naval Underwater Warfare Center, Newport, Testing Ranges, and pierside at Newport, Rhode Island (Section 3.0.3.3.1.2, Air Guns; Tables A.3.2.7.7, Semi-Stationary Equipment Testing, and A.3.3.1.1, Acoustic and Oceanographic Research, in Appendix A, Navy Activity Descriptions). Sounds produced by air guns are described in Section 3.0.3.3.1.2 (Air Guns).

Compared to offshore areas where air gun use would primarily affect invertebrates in the water column, air gun use at pierside locations would potentially affect a greater number of benthic and sessile invertebrates due to proximity to the bottom and structures (e.g., pilings) that may be colonized by invertebrates. Invertebrates such as sponges, hydroids, worms, bryozoans, bivalves, snails, and numerous types of crustaceans and echinoderms could be exposed to sound. Air gun use in offshore areas has the potential to affect pelagic invertebrates such as jellyfish and squid. Zooplankton could be affected by air gun use at any location. Available information indicates that zooplankton could be injured or killed, but injury to relatively large crustaceans (e.g., lobsters and crabs) would not be expected. Potential injury to squid located very near the source has been suggested but not demonstrated. It is unlikely that air guns would affect egg or larvae development due to the brief time that they would be exposed to impulsive sound (a few hundred milliseconds per firing). Activities conducted at pierside locations could potentially result in multiple exposures of sessile species or species with limited mobility to impulsive sound. Air gun use in offshore areas would be unlikely to affect individuals multiple times due to the relative mobility of invertebrates in the water column (passive and active movement) and the mobile nature of the sound source. Some number of invertebrates of various taxa exposed to air gun noise could experience a physiological stress response and would likely show startle reactions or short-term behavioral changes. For example, squid exposed to air gun noise would probably react behaviorally (e.g., inking, jetting, or changing swim speed or location in the water column), as these behaviors were observed in animals exposed to sound levels lower than the source levels of Navy air guns (distance from the source associated with these reactions was not provided). The results of one study suggests that affected individuals may exhibit less intense reactions when exposed to multiple air gun firings (McCauley et al., 2000a). In shallow water where air gun firing could cause sediment vibration, nearby benthic invertebrates could react behaviorally (e.g., shell closing or changes in foraging activity). Adult crustaceans may be less affected than other life stages.

Sound and sediment vibrations caused by air gun events would be brief, although multiple firings would occur per event. In addition, testing activities would be conducted infrequently. Although some individuals would be affected, the number would be small relative to overall population sizes, and activities would be unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

Testing activities involving air guns would not occur in the Key West Range Complex or South Florida Ocean Measurement Facility Testing Range, and would not intersect elkhorn or staghorn coral critical habitat. Pursuant to the ESA, the use of air guns during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.1.3.2 Impacts from Air Guns Under Alternative 2

Impacts from Air Guns Under Alternative 2 for Training Activities

There would be no air gun use associated with training activities. Therefore, air guns are not analyzed in this subsection.

Impacts from Air Guns Under Alternative 2 for Testing Activities

The locations, number of events, and potential effects associated with air gun use would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.1.3.1 (Impacts from Air Guns Under Alternative 1) for a discussion of impacts on invertebrates.

Testing activities involving air guns would not occur in the Key West Range Complex or South Florida Ocean Measurement Facility Testing Range, and would not intersect elkhorn or staghorn coral critical habitat. Pursuant to the ESA, the use of air guns during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.1.3.3 Impacts from Air Guns Under the No Action Alternative

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

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

3.4.3.1.4 Impacts from Pile Driving

Pile driving and removal involves both impact and vibratory methods. Impact pile driving produces repetitive, impulsive, broadband sound with most of the energy in lower frequencies where invertebrate hearing sensitivity is greater. Vibratory pile removal produces nearly continuous sound at a lower source level. See Section 3.0.3.3.1.3, Pile Driving, for a discussion of sounds produced during impact pile driving and vibratory pile removal.

Impacts on invertebrates resulting from pile driving and removal are considered in the context of impulsive sound and substrate vibration. Impact pile driving produces a pressure wave that is transmitted to the water column and the sediment (Reinhall & Dahl, 2011). The pressure wave may cause vibration within the sediment. Most acoustic energy would be concentrated below 1,000 Hz, which is within the general sound sensing range of invertebrates. Available information indicates that invertebrates may respond to particle motion and substrate vibration produced by pile driving or removal. As discussed in Section 3.4.3.1 (Acoustic Stressors), recent investigations have found effects to crustacean and mollusc species resulting from pile driving noise playback and substrate vibration (Roberts et al., 2015; Roberts et al., 2016a; Solan et al., 2016; Spiga, 2016). Responses include changes in chorusing (snapping shrimp), shell closing (clams and mussels), and changes in activity level (clams, lobsters, and hermit crabs). However, no statistically detectable changes were observed in brittlestars, suggesting that impacts may vary among taxa or species. While one study was conducted in a sheltered coastal area (Spiga, 2016), the others used small experimental tanks with maximum dimension of about 20 inches. Therefore, many of the effects were observed very close to the sound sources. Navy scientists are in the early stages of observing the response of marine life to pile driving in their unconfined environment using an adaptive resolution imaging sonar that allows observations in low-visibility estuarine waters. Samples acquired to date include the response (or lack thereof) of various fish and crabs to Navy pile driving in the Mid-Atlantic region (Chappell, 2018).

3.4.3.1.4.1 Impacts from Pile Driving Under Alternative 1

Impacts from Pile Driving Under Alternative 1 for Training Activities

Under Alternative 1, pile driving and removal associated with Elevated Causeway System placement would occur once per year in the nearshore and surf zone at one of the following locations: Virginia Capes Range Complex (Joint Expeditionary Base Little Creek, Virginia or Joint Expeditionary Base Fort Story, Virginia) or Navy Cherry Point Range Complex (Marine Corps Base Camp Lejeune, North Carolina) (Section 3.0.3.3.1.3, Pile Driving). Marine invertebrates in the area around a pile driving and vibratory removal site would be exposed to multiple impulsive sounds and other disturbance intermittently over an estimated 20 days during installation and 10 days during removal. Invertebrates could be exposed to impact noise for a total of 90 minutes per 24-hour period during installation, and could be exposed to noise and substrate vibration for a total of 72 minutes per 24-hour period during pile removal. It may be theorized that repeated exposures to impulsive sound could damage the statocyst of individuals of some taxa (e.g., crustaceans and cephalopods); however, experimental data on such effects are not available. Exposure to impulsive sound and substrate vibration would likely cause behavioral reactions in invertebrates located in the water column or on the bottom for some distance from the activities. Reactions such as shell closure or changes in activity could affect feeding, and auditory masking could affect other behaviors such as communication and predator avoidance. Repetitive impulses and substrate vibration may also cause short-term avoidance of the affected area by mobile invertebrates. Available experimental results do not provide estimates of the distance to which such reactions could occur. Although some number of individuals would experience physiological and behavioral effects, the activities would occur intermittently (one event occurring intermittently over approximately 30 days per year) in very limited areas and would be of short duration (maximum of 90 minutes per 24-hour period). Therefore, the number of invertebrates affected would be small compared to overall population numbers. Pile driving and removal activities would be unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

ESA-listed coral species and critical habitat do not occur in areas proposed for pile driving. Pursuant to the ESA, the use of pile driving during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Pile Driving Under Alternative 1 for Testing Activities

There would be no pile driving or removal associated with testing activities. Therefore, pile driving is not analyzed in this subsection.

3.4.3.1.4.2 Impacts from Pile Driving Under Alternative 2

Impacts from Pile Driving Under Alternative 2 for Training Activities

The locations, number of events, and potential effects associated with pile driving and removal would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.1.4.1 (Impacts from Pile Driving Under Alternative 1) for a discussion of impacts on invertebrates.

ESA-listed coral species and critical habitat do not occur in areas proposed for pile driving. Pursuant to the ESA, the use of pile driving during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Pile Driving Under Alternative 2 for Testing Activities

There would be no pile driving or removal associated with testing activities. Therefore, pile driving is not analyzed in this subsection.

3.4.3.1.4.3 Impacts from Pile Driving Under the No Action Alternative

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

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

3.4.3.1.5 Impacts from Vessel Noise

As described in Section 3.0.3.3.1.4 (Vessel Noise), naval vessels (including ships and small craft) produce low-frequency, broadband underwater sound that ranges over several sound levels and frequencies. Some invertebrate species would likely be able to detect the low-frequency component of vessel noise. Several studies, described in detail in Section 3.4.3.1 (Acoustic Stressors), have found physiological and behavioral responses in some invertebrate species in response to playback of vessel noise, although one study found no reaction by krill to an approaching vessel. Physiological effects included biochemical changes indicative of stress in crustacean species, decreased growth and reproduction in shrimp, and changes in sea hare embryo development. It is also possible that vessel noise may contribute to masking of relevant environmental sounds, such as predator detection or reef sounds. Low-frequency reef sounds are used as a settlement cue by the larvae of some invertebrate species. Behavioral effects resulting from boat noise playback have been observed in various crustacean, cephalopod, and bivalve species and include shell closing and changes in feeding, coloration, swimming, and other movements. Exposure to other types of non-impulsive noise (and therefore potentially relevant to vessel noise effects), including continuous sweeps and underwater turbine noise playback, has resulted in statocyst damage (squid and octopus), physiological stress, effects to larval development, and behavioral reactions. Noise exposure in several of the studies using boat and other continuous noise sources occurred over a duration of 3.5 to 30 minutes to captive individuals unable to escape the stimulus. In other studies, noise playback ranged from hours to days (and up to 3 months in one investigation) of continuous or intermittent exposure. Given the duration of exposure, direct applicability of the results to Navy training and testing activities is uncertain for mobile species. However, it is possible that invertebrates in the Study Area that are exposed to vessel noise could exhibit similar reactions.

While commercial vessel traffic and associated noise is relatively steady over time, Navy traffic is episodic in the ocean. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours to a few weeks. 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 days within a given area. In the East Coast Exclusive Economic Zone, Navy ships are estimated to contribute only roughly 1 percent of the total large vessel broadband energy noise (Mintz & Filadelfo, 2011). However, the percentage of naval vessel traffic in port areas with Navy installations, such as Norfolk and Mayport, is probably greater than 1 percent.

3.4.3.1.5.1 Impacts from Vessel Noise Under Alternative 1

Impacts from Vessel Noise Under Alternative 1 for Training Activities

Under Alternative 1, naval vessels would be used during many of the proposed activities, and naval vessel noise associated with vessel transit during training could occur in all of the range complexes and inshore waters throughout the Study Area. Activities that occur in the offshore component of the Study Area may last from a few hours to a few weeks, and vessels would generally be widely dispersed. However, exposure to naval vessel noise would be greatest in the areas of highest naval vessel traffic, which generally occurs in the Virginia Capes and Jacksonville Range Complexes. Noise exposure would be particularly concentrated near naval port facilities, especially around and between the ports of Norfolk, Virginia, and Jacksonville, Florida. Activities that occur in inshore waters can last from a few hours to up to 12 hours of daily movement per vessel per activity, and can involve speeds greater than 10 knots. Vessels that would operate within inshore waters are generally smaller than those in offshore waters (small craft less than 50 ft.). Vessel movements in the inshore waters of the Study Area occur on a more regular basis than the offshore activities, and generally occur in more confined waterways (primarily in the Lower Chesapeake Bay and James River). Information on the number and location of activities using vessels, as well as the number of hours of operation for inshore waters, is provided in Section 3.0.3.3.4.1 (Vessels and In-Water Devices).

Marine invertebrates capable of sensing sound may alter their behavior or experience masking of other sounds if exposed to vessel noise. Because the distance over which most marine invertebrates are expected to detect sounds is limited, and because most vessel noise is transient or intermittent (or both), most behavioral reactions and masking effects from Navy activities would likely be short term, ceasing soon after Navy vessels leave an area. An exception would be areas in and around port navigation channels and inshore waters that receive a high volume of ship or small craft traffic, where sound disturbance would be more frequent. The relatively high frequency and intensity of vessel traffic in many inshore training areas may have given organisms an opportunity to adapt behaviorally to a noisier environment. For example, recent survey work by the Virginia Institute of Marine Science suggests that large populations of oysters inhabit Navy piers in the Chesapeake Bay that have persisted despite a history of chronic vessel noise (Horton, 2016). Without prolonged exposure to nearby sounds, measurable impacts are not expected. In general, intermittent vessel noise produced during training activities may briefly impact some individuals, but exposures are not expected to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations. Concentrated vessel operation in areas such as port navigation channels could result in repeated noise exposure and chronic physiological or behavioral effects to individuals of local invertebrate subpopulations, particularly sessile species, located near the sound source. However, vessel noise would not be expected to adversely affect the viability of common or widely distributed invertebrate species in navigation channels or near naval port facilities.

Some adults of ESA-listed corals could potentially detect the low-frequency component of nearby vessel noise, although there are no studies of the effects of vessel noise on corals. Coral larvae exposed to vessel noise near a reef could experience temporary masking and brief disruption of settlement cues. Mapped areas of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks would be avoided during precision anchoring and explosive mine countermeasure and neutralization activities. In addition, mapped areas of shallow-water coral reefs would be avoided during explosive and non-explosive gunnery, missile, and bombing activities. Avoidance of these areas would decrease vessel transit and associated vessel noise through areas supporting shallow-water corals, including ESA-listed staghorn and elkhorn corals. Vessel noise would not affect the physical components designated critical habitat for elkhorn coral and staghorn coral. Pursuant to the ESA, vessel noise produced during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Vessel Noise Under Alternative 1 for Testing Activities

Under Alternative 1, naval vessels would be used during many of the proposed activities, and naval vessel noise associated with testing could occur in all of the range complexes and testing ranges throughout the Study Area, and in some inshore waters. However, exposure to naval vessel noise would be greatest in the areas of highest naval vessel traffic, which generally occurs in the Virginia Capes and Jacksonville Range Complexes. Noise exposure would be particularly concentrated near naval port facilities, especially around and between the ports of Norfolk, Virginia, and Jacksonville, Florida. Information on the number and location of activities using vessels, as well as the number of hours of operation for inshore waters, is provided in Section 3.0.3.3.4.1 (Vessels and In-Water Devices).

Any marine invertebrate capable of sensing sound may alter its behavior or experience masking of other sounds if exposed to vessel noise. Because the distance over which most marine invertebrates are expected to detect sounds is limited and because most vessel noise is transient or intermittent (or both), most behavioral reactions and masking effects from Navy activities would likely be short term, ceasing soon after Navy vessels leave an area. An exception would be areas in and around port navigation channels and inshore waters that receive a high volume of ship or small craft traffic, where sound disturbance would be more frequent. The relatively high frequency and intensity of vessel traffic in many inshore areas may have given organisms an opportunity to adapt behaviorally to a noisier environment. For example, recent survey work by the Virginia Institute of Marine Science suggests that large populations of oysters inhabit Navy piers in the Chesapeake Bay that have persisted despite a history of chronic vessel noise (Horton, 2016). Without prolonged exposure to nearby sounds, measurable impacts are not expected. In general, intermittent vessel noise produced during testing activities may briefly impact some individuals, but exposures are not expected to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations. Concentrated vessel operation in areas such as port navigation channels could result in repeated noise exposure and chronic physiological or behavioral effects to individuals of local invertebrate subpopulations, particularly sessile species, located near the sound source. However, vessel noise would not be expected to adversely affect the viability of common or widely distributed invertebrate species in navigation channels or near naval port facilities.

Some adults of ESA-listed corals could potentially detect the low-frequency component of nearby vessel noise, and coral larvae exposed to vessel noise near a reef could experience temporary masking and brief disruption of settlement cues. Mapped areas of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks would be avoided during explosive mine countermeasure and neutralization activities. In addition, mapped areas of shallow-water coral reefs would be avoided during explosive and non-explosive gunnery, missile, rocket, and bombing activities and mine-laying activities. Avoidance of these areas would decrease vessel transit and associated vessel noise through areas supporting shallow-water corals, including ESA-listed staghorn and elkhorn corals. Vessel noise would not affect the physical components of designated critical habitat for elkhorn coral and staghorn coral. Pursuant to the ESA, vessel noise produced during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.1.5.2 Impacts from Vessel Noise Under Alternative 2

Impacts from Vessel Noise Under Alternative 2 for Training Activities

Under Alternative 2, potential impacts to invertebrates resulting from vessel noise associated with training activities would be similar to those discussed for activities under Alternative 1. Vessel use in the Study Area would increase by a very small amount (about 1 percent) due to differences in the number of events such as Composite Training Unit Exercises. However, the increase would not result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.1.5.1 (Impacts from Vessel Noise Under Alternative 1) for a discussion of potential impacts.

As discussed in Section 3.4.3.1.5.1 (Impacts from Vessel Noise Under Alternative 1), mapped areas of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks would be avoided during precision anchoring and explosive mine countermeasure and neutralization activities. In addition, mapped areas of shallow-water coral reefs would be avoided during explosive and non-explosive gunnery, missile, and bombing activities. Avoidance of these areas would decrease vessel transit and associated vessel noise through areas supporting shallow-water corals, including ESA-listed staghorn and elkhorn corals. Vessel noise would not affect the physical components of designated critical habitat for elkhorn coral and staghorn coral. Pursuant to the ESA, vessel noise produced during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Vessel Noise Under Alternative 2 for Testing Activities

Under Alternative 2, potential impacts to invertebrates resulting from vessel noise associated with testing activities would be similar to those discussed for activities under Alternative 1. Vessel use in the Study Area would increase by a very small amount (less than 1 percent). However, the increase would not result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.1.5.1 (Impacts from Vessel Noise Under Alternative 1) for a discussion of potential impacts.

As discussed in Section 3.4.3.1.5.1 (Impacts from Vessel Noise under Alternative 1), mapped areas of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks would be avoided during explosive mine countermeasure and neutralization activities. In addition, mapped areas of shallow-water coral reefs would be avoided during explosive and non-explosive gunnery, missile, rocket, and bombing activities and mine-laying activities. Avoidance of these areas would decrease vessel transit and associated vessel noise through areas supporting shallow-water corals, including ESA-listed staghorn and elkhorn corals. Vessel noise would not affect the physical components of designated critical habitat for elkhorn coral and staghorn coral. Pursuant to the ESA, vessel noise produced during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.1.5.3 Impacts from Vessel Noise Under the No Action Alternative

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

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

3.4.3.1.6 Impacts from Aircraft Noise

Aircraft and missile overflight noise is not applicable to invertebrates due to the very low transmission of sound pressure across the air/water interface and will not be analyzed further in this section.

3.4.3.1.7 Impacts from Weapons Noise

As discussed in Section 3.0.3.3.1.6 (Weapon Noise), noise associated with weapons firing and the impact of non-explosive munitions could occur during training or testing events. In-water noise would result from naval gunfire (muzzle blast), bow shock waves from supersonic projectiles, missile and target launch, and vibration from a blast propagating through a ship's hull. In addition, larger non-explosive munitions could produce low-frequency impulses when striking the water, depending on the size, weight, and speed of the object at impact. Small- and medium-caliber munitions would not produce substantial impact noise.

Underwater sound produced by weapons firing, launch, and impact of non-explosive practice munitions would be greatest near the surface and would attenuate with depth. However, the potential for in-air weapons noise to impact invertebrates would be small. Much of the energy produced by muzzle blasts and flying projectiles is reflected off the water surface. As discussed in Section 3.0.3.3.1.6 (Weapon Noise), sound generally enters the water only in a cone beneath the blast or projectile trajectory (within 13 to 14 degrees of vertical for muzzle blast noise, and 65 degrees behind the projectile in the direction of fire for projectile shock waves). An SEL of 180 to 185 dB re 1 μPa^2-s was measured at water depth of 5 ft. directly below the muzzle blast of the largest gun analyzed, at the firing position closest to the water. Different weapons and angles of fire would produce less sound in the water. Bow waves from supersonic projectiles produce a brief "crack" noise at the surface, but transmission of sound into the water is minimal. Launch noise fades rapidly as the missile or target moves downrange and the booster burns out. Hull vibration from large-caliber gunfire produces only a small level of underwater noise. For example, analysis of 5-in. gun firing found that energy transmitted into the water by hull vibration is only 6 percent of that produced by the muzzle blast. Compared to weapons firing, launches, and hull vibration, impulsive sound resulting from non-explosive practice munition strikes on the water surface could affect a somewhat larger area, though far less than an explosive blast. Underwater sound would generally be associated only with relatively large munitions impacting at high speed.

Based on the discussion above, invertebrates would likely only be affected by noise produced by muzzle blasts and impact of large non-explosive practice munitions. Impacts would likely be limited to pelagic invertebrates, such as squid, jellyfish, and zooplankton, located near the surface. Injury and physiological stress has not been found in limited studies of invertebrates exposed to impulsive sound levels comparable to those produced beneath the muzzle blast of a 5-in. gun. Behavioral reactions have not been found in crustaceans, but have been observed for squid. While squid could display short-term startle response, behavioral reactions in response to sound is not known for jellyfish or zooplankton. Zooplankton may include gametes, eggs, and larval forms of various invertebrate species, including corals. Although prolonged exposure to repeated playback of nearby impulsive sound (air guns) has resulted in developmental effects to larvae and eggs of some invertebrate species, brief exposure to a single or limited number of muzzle blasts or munition impacts would be unlikely to affect development. Other factors would limit the number and types of invertebrates potentially affected. Most squid are active near the surface at night, when weapons firing and launch occur infrequently. Weapons firing and launch typically occurs greater than 12 NM from shore, which because of the greater water depths would substantially limit the sound level reaching the bottom. Therefore, impacts to benthic invertebrates (e.g., bivalve molluscs, worms, and crabs) are unlikely.

3.4.3.1.7.1 Impacts from Weapons Noise Under Alternative 1

Impacts from Weapons Noise Under Alternative 1 for Training Activities

Under Alternative 1, invertebrates would be exposed to noise primarily from weapons firing and impact of non-explosive practice munitions during training activities. Noise associated with these activities could be produced throughout the Study Area, including when ships are in transit, but would typically be concentrated in the Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico 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. Small caliber weapons firing could occur throughout the Study Area.

Noise produced by these activities would consist of a single or several impulses over a short period. Impulses resulting from muzzle blasts and non-explosive practice munitions impact would likely affect only individuals near the surface, and are not likely to result in injury. Some invertebrates may exhibit startle reactions (e.g., abrupt changes in swim speed or direction). For example, based on observed reactions to other impulsive sounds (air guns), squid located near the surface in the vicinity of a firing event could show startle reactions such as inking or jetting. Impacts of non-explosive practice munitions could affect a comparatively larger volume of water and associated invertebrates. The number of organisms affected would depend on the area exposed and the invertebrate density. Squid and zooplankton are typically more abundant near the surface at night, when weapon firing occurs infrequently. In addition, most weapons firing would take place in offshore waters, decreasing the potential for impacts to benthic invertebrates and coral eggs and larvae.

Impacts would be of brief duration and limited to a relatively small volume of water near the surface. It is expected that only a small number of pelagic invertebrates (e.g., squid, jellyfish, and zooplankton) would be exposed to weapons firing and impact noise. Squid and zooplankton would be less abundant during the day, when weapons firing typically occurs, and jellyfish are not known to react to sound. The activities would be unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

ESA-listed coral species and designated critical habitat would not likely be exposed to noise from weapons firing, launch, and impact of non-explosive practice munitions during training activities because those activities are generally conducted in offshore waters where shallow-water corals do not typically occur. Noise produced at the surface or as a result of vessel hull vibration would be unlikely to cause physiological or behavioral responses in corals due to their limited sound detection range. Noise produced by weapons firing, launch, and impact of non-explosive practice items would not affect the characteristics of elkhorn coral and staghorn coral critical habitat. Pursuant to the ESA, weapons noise produced during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Weapons Noise Under Alternative 1 for Testing Activities

Under Alternative 1, invertebrates would be exposed to noise primarily from weapons firing and impact of non-explosive practice munitions during testing activities. Testing activities would be concentrated in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes, and could also occur in the Naval Surface Warfare Center, Panama City Testing Range. 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. Small caliber weapons firing could occur throughout the Study Area.

Noise produced by these activities would consist of a single or several impulses over a short period. Impulses resulting from muzzle blasts and non-explosive practice munitions impact would likely affect only individuals near the surface, and are not likely to result in injury. Some invertebrates may exhibit startle reactions (e.g., abrupt changes in swim speed or direction). For example, based on observed reactions to other impulsive sounds (air guns), squid located near the surface in the vicinity of a firing event could show startle reactions such as inking or jetting. Impacts of non-explosive practice munitions could affect a comparatively larger volume of water and associated number of invertebrates. The number of organisms affected would depend on the area exposed and the invertebrate density. Squid and zooplankton are typically more abundant near the surface at night, when weapon firing occurs infrequently. In addition, most weapons firing would take place in offshore waters, decreasing the potential for impacts to benthic invertebrates and coral eggs and larvae.

Impacts would be of brief duration and would be limited to a relatively small volume of water near the surface. It is expected that only a small number of pelagic invertebrates (e.g., squid, jellyfish, and zooplankton) would be exposed to weapons firing and impact noise. Squid and zooplankton would be less abundant during the day, when weapons firing typically occurs, and jellyfish are not known to react to sound. The activities would be unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

Testing activities would be conducted in the Key West Range Complex, where ESA-listed corals (and associated coral eggs and larvae) and elkhorn and staghorn coral critical habitat occur. However, ESA-listed coral species and designated critical habitat would not likely be exposed to noise from weapons firing, launch, and impact of non-explosive practice munitions during testing activities because those activities are generally conducted in offshore waters where shallow-water corals do not typically occur. Noise produced at the surface or as a result of vessel hull vibration would be unlikely to cause physiological or behavioral responses in corals due to their limited sound detection range. Noise produced by weapons firing, launch, and impact of non-explosive practice items would not affect the characteristics of elkhorn coral and staghorn coral critical habitat. Pursuant to the ESA, weapons noise produced during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.1.7.2 Impacts from Weapons Noise Under Alternative 2

Impacts from Weapons Noise Under Alternative 2 for Training Activities

The locations, number of events, and potential effects associated with weapons firing, launch, and non-explosive practice munition impact noise for training activities would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.1.5.1 (Impacts from Weapons Noise Under Alternative 1) for a discussion of impacts on invertebrates.

Pursuant to the ESA, weapons noise produced during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Weapons Noise Under Alternative 2 for Testing Activities

Under Alternative 2, the location of testing activities would be the same as those described for Alternative 1, and potential impacts to invertebrates would be similar (refer to Section 3.4.3.1.5.1, Impacts from Weapons Noise Under Alternative 1). The only difference between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While the types of expected impacts to any individual invertebrate or group of invertebrates capable of detecting sounds produced during testing activities would remain the same, more animals could be affected because the number of munitions potentially used during testing activities under Alternative 2 would be greater. It is expected that only a small number of pelagic invertebrates (e.g., squid, jellyfish, and zooplankton) would be exposed. Squid and zooplankton would be less abundant near the surface during the day, when weapons firing typically occurs, and jellyfish are not known to react to sound. The activities would be unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

ESA-listed coral species and designated critical habitat would not likely be exposed to noise from weapons firing, launch, and impact of non-explosive practice munitions during testing activities because those activities are generally conducted in offshore waters where shallow-water corals do not typically occur. Noise produced at the surface or as a result of vessel hull vibration would be unlikely to cause physiological or behavioral responses in corals due to their limited sound detection range. Noise produced by weapons firing, launch, and impact of non-explosive practice munitions would not affect the characteristics of elkhorn coral and staghorn coral critical habitat. Pursuant to the ESA, weapons noise produced during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.1.7.3 Impacts from Weapons Noise Under the No Action Alternative

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

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

3.4.3.1.8 Summary of Potential Acoustic Impacts

Invertebrates would be exposed to potential acoustic stressors resulting from sonar and other transducers; pile driving; air guns; weapons firing, launch, and non-explosive practice munition impact noise; and vessel noise. Based on currently available information, invertebrates would only sense water particle motion near a sound source and at low frequencies, which limits the distance from the source in which individual invertebrates would potentially be exposed to acoustic impacts. The potential for injury would be limited to invertebrates occurring very close to an impulsive sound such as an air gun. Impacts would primarily consist of physiological stress or behavioral reactions. Most sound exposures would occur in offshore areas and near the surface, where pelagic species such as squid, jellyfish, and zooplankton would be affected. Squid and some zooplankton species occur infrequently at the surface during the day, when most Navy activities would take place. Overall, there would be comparatively fewer impacts to benthic species. Exceptions would include pierside sonar and air gun use, and concentration of vessel operation in certain areas, where sessile or sedentary individuals could be repeatedly exposed to acoustic stressors. Most sound exposures would be brief and transient and would affect a small number of individuals.

3.4.3.2 Explosive Stressors

3.4.3.2.1 Background

Aspects of explosive stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Explosions produce pressure waves with the potential to cause injury or physical disturbance due to rapid pressure changes, as well as loud, impulsive, broadband sounds. Impulsive sounds are characterized by rapid pressure rise times and high peak pressures (Appendix D, Acoustic and Explosive Concepts). Potential impacts on invertebrates resulting from the pressure wave and impulsive sound resulting from a detonation are discussed in this section. 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 they no longer pose a threat. Given the small range of effects due to fragments, the potential for impacts on invertebrates at the population or subpopulation level would be negligible. Therefore, the potential for fragmentation to impact invertebrates is not discussed further in this analysis.

Explosions may impact invertebrates at the water surface, in the water column, or on the bottom. The potential for impacts is influenced by typical detonation scenarios and invertebrate distribution. The majority of explosions would occur in the air or at the surface, with relatively few at the bottom (Appendix A, Navy Activity Descriptions), which would decrease the potential for impacts to benthic invertebrate species. Surface explosions typically occur during the day at offshore locations more than 12 NM from shore. There is a general pattern of lower invertebrate abundance in offshore portions of the Study Area compared to relatively productive estuarine and nearshore waters. Therefore, the typical offshore location of detonations would result in fewer invertebrates potentially exposed to detonation effects. In addition, invertebrate abundances in offshore surface waters tend to be lower during the day, when surface explosions typically occur, than at night.

In general, an explosion may result in direct trauma and mortality due to the associated rapid pressure changes. For example, gas-containing organs such as the swim bladder in many fish species and the lungs of marine mammals are subject to rapid contraction and overextension (potentially causing rupture) when exposed to explosive shock waves. Most marine invertebrates lack air cavities and are therefore comparatively less vulnerable to damaging effects of pressure waves. A report summarizing the results of all known historical experiments (from 1907 to the 1980s) involving invertebrates and detonations concluded that marine invertebrates are generally insensitive to pressure-related damage from underwater explosions (Keevin & Hempen, 1997). Limited studies of crustaceans have examined mortality rates at various distances from detonations in shallow water (Aplin, 1947; Chesapeake Biological Laboratory, 1948; Gaspin et al., 1976). Similar studies of molluscs have shown them to be more resistant than crustaceans to explosive impacts (Chesapeake Biological Laboratory, 1948; Gaspin et al., 1976). Other invertebrates, such as sea anemones, polychaete worms, isopods, and amphipods, were observed to be undamaged in areas near detonations (Gaspin et al., 1976). Data from these experiments were used to develop curves that estimate the distance from an explosion beyond which at least 90 percent of certain adult benthic marine invertebrates would survive, depending on the weight of the explosive (Young, 1991) (Figure 3.4-2). For example, 90 percent of crabs would survive a 200-lb. explosion if they are greater than about 350 ft. from the source, and shrimp, lobster, and oysters are less sensitive (i.e., greater survivability) to underwater explosions than crabs. Similar information on the effects of explosions to planktonic invertebrates and invertebrate larvae is not available.

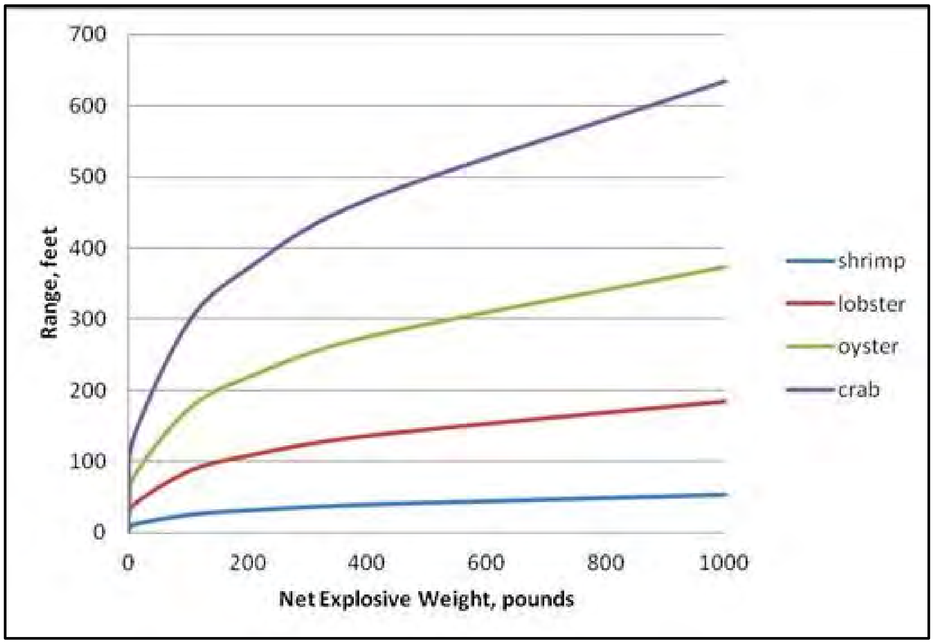

Figure 3.4-2: Prediction of Distance to 90 Percent Survivability of Marine Invertebrates Exposed to an Underwater Explosion (Young, 1991)

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 marine invertebrates on or near the bottom, depending on the species and the distance from the explosion. Taxonomic groups typically associated with the bottom, such as sponges, marine worms, crustaceans, echinoderms, corals, and molluscs, could be affected. Net explosive weight (NEW) for activities involving detonations on or near the bottom is relatively low. Most detonations occurring on or near the bottom would have a NEW of 60 lb. or less, although some explosives would be up to 3,625 lb. NEW. Based on the estimates shown on Figure 3.4-2, most benthic marine invertebrates beyond approximately 275 ft. from a 60-lb. blast would survive. The potential mortality zone for some taxa (e.g., shrimp, lobsters, worms, amphipods) would be substantially smaller. A blast near the bottom could disturb sessile invertebrates such as mussels and hard substrate suitable for their colonization. A blast in the vicinity of hard corals could cause direct impact to coral polyps or early life-stages of pre-settlement corals, or fragmentation and siltation of the corals. For example, in one study, moderate to substantial recovery from a single small blast directly on a reef was observed within 5 years, but reef areas damaged by multiple blasts showed no evidence of recovery during the 6-year observation period (Fox & Caldwell, 2006). In another study, modeling results indicated that deep-water corals off Alaska damaged by trawling activities could require over 30 years to recover 80 percent of the original biomass (Rooper et al., 2011). The extent of trawling damage is potentially greater than that associated with detonations due to the small footprints of detonations compared to the larger surface area typically affected by trawling, as well as the avoidance of known shallow-water coral reefs and live hard bottom habitat during activities involving detonations. While the effects of trawling activities and underwater detonations are not directly comparable, the trawling model results illustrate the extended recovery time that may be required for deep-water coral regrowth following physical disturbance.

Impacts to benthic invertebrates in deeper water would be infrequent because most offshore detonations occur in the air or at the surface. Benthic invertebrates in the abyssal zone (generally considered to be deeper than about 6,000 ft.) seaward of the coastal large marine ecosystems are sparsely distributed and tend to be concentrated around hydrothermal vents and cold seeps. These topographic features are typically associated with steep or high-relief areas of the continental shelf break (e.g., canyons, outcrops) or open ocean (e.g., seamounts, Mid-Atlantic Ridge).

Underwater surveys of a Navy bombing range in the Pacific Ocean (Farallon De Medinilla) were conducted from 1999 to 2012 (Smith & Marx, 2016). Although Farallon De Medinilla is a land range, bombs and other munitions occasionally strike the water. A limited number of observations of explosion-related effects were reported, and the results are summarized here to provide general information on the types of impacts that may occur. However, the effects are not presumed to be broadly applicable to Navy training and testing activities. During the 2010 survey, it was determined that a blast of unknown size (and therefore of unknown applicability to proposed training and testing activities) along the waterline of a cliff ledge caused mortality to small oysters near the impact point. Corals occurring within 3 m of the affected substrate were apparently healthy. A blast crater on the bottom that was 5 m in diameter and 50 cm deep, presumably resulting from a surface detonation, was observed during one survey in water depth of 12 m. Although it may be presumed that corals or other invertebrates located within the crater footprint would have been damaged or displaced, evidence of such impacts was not detected. The blast occurred in an area of sparse coral coverage and it is therefore unknown whether coral was present in the crater area prior to the blast.

The applicability of the mortality distance estimates shown on Figure 3.4-2 to invertebrates located in the water column is unknown. However, detonations that occur near the surface release a portion of the explosive energy into the air rather than the water, reducing impacts to invertebrates in the water column. In addition to effects caused by a shock wave, organisms in an area of cavitation that forms near the surface above a large underwater detonation could be killed or injured. Cavitation is where the reflected shock wave creates a region of negative pressure followed by a collapse, or water hammer (see Appendix D, Acoustic and Explosive Concepts). The number of organisms affected by explosions at the surface or in the water column would depend on the size of the explosive, the distance of organisms from the explosion, and the specific geographic location within the Study Area. As discussed previously, many invertebrates that occur near the surface at night (e.g., squid and zooplankton) typically move down in the water column during the day, making them less vulnerable to explosions when most Navy activities involving detonations occur.

Marine invertebrates beyond the range of mortality or injurious effects may detect the impulsive sound produced by an explosion. At some distance, impulses lose their high pressure peak and take on characteristics of non-impulsive acoustic waves. Invertebrates that detect impulsive or non-impulsive sounds may experience stress or exhibit behavioral reactions in response to the sound (see Section 3.4.3.1.1, Background). Repetitive impulses during multiple explosions, such as during a surface firing exercise, may be more likely to cause avoidance reactions. However, the distance to which invertebrates are likely to detect sounds is limited due to their sensitivity to water particle motion caused by nearby low-frequency sources. Sounds produced in water during training and testing activities, including activities that involve multiple impulses, occur over a limited duration. Any auditory masking, in which the sound of an impulse could prevent detection of other biologically relevant sounds, would be very brief.

3.4.3.2.2 Impacts from Explosives

3.4.3.2.2.1 Impacts from Explosives Under Alternative 1

Impacts from Explosives Under Alternative 1 for Training Activities

Under Alternative 1, marine invertebrates would be exposed to surface and underwater explosions and associated underwater impulsive sounds from high-explosive munitions (including bombs, missiles, torpedoes, and projectiles), mines, and demolition charges. Explosives would be used throughout the Study Area, but most typically in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems and in the Gulf Stream Open Ocean Area. The only underwater explosions that would occur on or near the bottom in the Key West Range Complex would result from use of 5- to 20-lb. charges. A discussion of explosives, including explosive source classes, is provided in Section 3.0.3.3.2 (Explosive Stressors). The largest source class proposed for training under Alternative 1 is E12 (650 to 1,000 lb. NEW), used during bombing exercises (air-to-surface) and sinking exercises.

In general, explosive events would consist of a single explosion or a few smaller explosions over a short period, and would occur infrequently over the course of a year. With the exception of mine warfare, demolition, and a relatively small number of other training events that occur in shallow water close to shore (typically in the same locations that are regularly disturbed), most detonations would occur in water depths greater than 200 ft. (but still at the surface) and greater than 3 to 9 NM from shore. As water depth increases away from shore, benthic invertebrates would be less likely to be impacted by detonations at or near the surface because the impact of the underwater impulsive sounds would be dampened. Pelagic invertebrates, such as squid and zooplankton, are typically less abundant near the surface during the day, when explosions typically occur. In addition, detonations near the surface would release a portion of their explosive energy into the air, reducing the potential for impacts to pelagic invertebrates.

Mine warfare activities are typical examples of activities involving detonations on or near the bottom in nearshore waters. Invertebrates in these areas are adapted to frequent disturbance from storms and associated sediment redistribution. Studies of the effects of large-scale sediment disturbance, such as dredging and sediment borrow projects, have found recovery of benthic communities over a period of weeks to years (Posey & Alphin, 2002; U.S. Army Corps of Engineers, 2012). Recovery time is variable and may be influenced by multiple factors, but is generally faster in areas dominated by sand and moderate to strong water movement. The area of bottom habitat disturbed by explosions would be less than that associated with dredging or other large projects, and would occur mostly in soft bottom areas that are regularly disturbed by natural processes such as water currents and waves. It is therefore expected that areas affected by detonations would rapidly be recolonized (potentially within weeks) by recruitment from the surrounding invertebrate community. Craters resulting from detonations in the soft bottom would be filled and smoothed by waves and long-shore currents over time, resulting in no permanent change to bottom profiles that could affect invertebrate species assemblages. The time required to fill craters would depend on the size and depth, with deeper craters likely requiring more time to fill (U.S. Army Corps of Engineers, 2001). The amount of bottom habitat impacted by explosions would be a very small percentage of the habitat available in the Study Area. The total bottom area potentially disturbed by explosions over a 5-year period would be approximately 44 acres (see Table F-25, Potential Impact from Explosives On or Near the Bottom for Training Activities Under Alternatives 1 and 2 Over Five Years, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). Of this total, less than 0.03 percent of the total area of each habitat type (hard, intermediate, and soft) would be impacted, including less than 0.01 percent of hard bottom habitat. This affected area occurs within the context of over 100 million acres of undersea space encompassed by the range complexes associated with mine neutralization training activities (Gulf of Mexico, Jacksonville, Key West, Navy Cherry Point, and Virginia Capes Range Complexes).

Many corals and hard bottom invertebrates are sessile, fragile, and particularly vulnerable to shock wave impacts. Many of these organisms are slow-growing and could require decades to recover (Precht et al., 2001). However, most explosions would occur at or near the water surface and offshore, reducing the likelihood of bottom impacts on shallow-water corals.

In summary, explosives produce pressure waves that can harm invertebrates in the vicinity of where they typically occur: mostly offshore surface waters where only zooplankton, squid, and jellyfish are less abundant during the day when training activities typically occur. Exceptions occur where explosives are used on the bottom within nearshore or inshore waters on or near sensitive hard bottom communities that are currently not mapped or otherwise protected; shallow-water coral reefs are protected from such explosions whereas other live hard bottom communities are protected to the extent they are included in current mitigation measures. Soft bottom communities are resilient to occasional disturbances. Accordingly, the overall impacts of explosions on widespread invertebrate populations would likely be undetectable. Although individuals of widespread marine invertebrate species would likely be injured or killed during an explosion, the number of such invertebrates affected would be small relative to overall population sizes, and activities would be unlikely to impact survival, growth, recruitment, or reproduction of populations or subpopulations. Species with limited distribution, such as stony corals, would be of greater concern.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks. The mitigation will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including several areas inhabited by ESA-listed coral species. In addition, procedural mitigations include the requirement to avoid jellyfish aggregations during sinking exercises (Section 5.3.3.6, Sinking Exercises) and ship shock trials (Section 5.3.3.11, Ship Shock Trials).

Due to the mitigation described above, the probability of shallow-water corals being exposed to detonation effects is low. Explosions on or over soft bottom up-current from shallow-water coral reefs could kill or injure some coral larvae that could have otherwise settled on suitable habitat down-current. However, this situation is unlikely considering most water-based training areas in the Key West OPAREA do not intersect shallow-water coral reefs. Exposure in the context of shock wave impacts would occur only if explosions inadvertently occurred near unmapped shallow-water coral reefs or other substrate potentially supporting shallow-water corals (e.g., hard substrate in the mesophotic zone). Although such a scenario is unlikely, there is a small potential for exposure. Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed coral species and critical habitat. The Navy has consulted with the NMFS, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Explosives Under Alternative 1 for Testing Activities

Under Alternative 1, marine invertebrates could be exposed to surface and underwater explosions from high-explosive munitions (including bombs, missiles, torpedoes, and projectiles), mines, demolition charges, explosive sonobuoys, and ship shock trial charges. Explosives would be used throughout the Study Area, but most typically in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and in the Gulf Stream Open Ocean Area. The largest source classes proposed for testing under Alternative 1 would be used in the Northeast U.S. Continental Shelf Large Marine Ecosystem, Southeast U.S. Continental Shelf Large Marine Ecosystem, or in the Gulf Stream Open Ocean Area during ship shock trials in the Virginia Capes, Jacksonville, or Gulf of Mexico Range Complexes. Large ship shock trials could use charges up to source class E17 (14,500 to 58,000 lb. NEW), while small ship shock trials could use charges up to source class E16 (7,250 to 14,500 lb. NEW). Each full ship shock trial would use up to four of these charges in total (each one detonated about a week apart, although smaller charges may be detonated on consecutive days). Use of explosives is described in Section 3.0.3.3.2 (Explosive Stressors).

In general, explosive events would consist of a single explosion or a few smaller explosions over a short period, and would occur infrequently over the course of a year. With the exception of mine warfare, demolition charges, and line charge testing events that occur in shallow water close to shore (typically in the same locations that are regularly disturbed), most detonations would occur in areas with water depths greater than 200 ft. (but detonations still would occur at the surface) and greater than 3 NM from shore. Ship shock charges would occur off the continental shelf in water depths greater than 600 ft. As water depth increases away from shore, benthic invertebrates would be less likely to be impacted by detonations at or near the surface. The invertebrates that occur at or near the surface consist primarily of squid, jellyfish, and zooplankton, which are typically active near the surface at night, when explosions occur infrequently. In addition, detonations near the surface would release a portion of their explosive energy into the air, reducing the potential for impacts to pelagic invertebrates.

Mine warfare activities are typical examples of activities involving detonations on or near the bottom in nearshore waters. Invertebrates in these areas are adapted to frequent disturbance from storms and associated sediment redistribution. Studies of the effects of large-scale sediment disturbance such as dredging and sediment borrow projects have found recovery of benthic communities over a period of weeks to years (Posey & Alphin, 2002; U.S. Army Corps of Engineers, 2012). Recovery time is variable and may be influenced by multiple factors, but is generally faster in areas dominated by sand and moderate to strong water movement. The area of bottom habitat disturbed by explosions would be less than that associated with dredging or other large projects, and would occur mostly in soft bottom areas that are regularly disturbed by natural processes such as water currents and waves. It is therefore expected that areas affected by detonations would be recolonized rapidly (potentially within weeks) by recruitment from the surrounding invertebrate community. Craters resulting from detonations in the soft bottom would be filled and smoothed by waves and long-shore currents over time, resulting in no permanent change to bottom profiles that could affect invertebrate species assemblages. The time required to fill craters would depend on the size and depth, with deeper craters likely requiring more time to fill (U.S. Army Corps of Engineers, 2001). The total bottom area potentially disturbed by explosions over a 5-year period would be approximately 43 acres (see Table F-26, Potential Impact from Explosives On or Near the Bottom for Testing Activities Under Alternatives 1 and 2 Over Five Years, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). Of this total, less than 0.04 percent of the total area of each habitat type (hard, intermediate, and soft) would be impacted.

In summary, explosives produce pressure waves that can harm invertebrates in the immediate vicinity of where the explosions occur. The majority of explosions would occur in offshore surface waters where the predominant invertebrate species are prevalent mostly at night when testing activities typically occur infrequently. Exceptions occur where explosives are used on the bottom within nearshore or inshore waters, on or near sensitive hard bottom communities that are currently not mapped or otherwise protected; shallow-water coral reefs are protected from such explosions whereas other live hard bottom communities are protected to the extent they are included in current mitigation measures. Soft bottom communities are resilient to occasional disturbances. Accordingly, the overall impacts of explosions on widespread invertebrate populations would likely be undetectable because of the small spatial and temporal scale of potential changes. Although individual marine invertebrates would likely be injured or killed during an explosion, the activities would be unlikely to impact survival, growth, recruitment, or reproduction of marine invertebrate populations or subpopulations.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks. The mitigation will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including several areas inhabited by ESA-listed coral species. In addition, procedural mitigations include the requirement to avoid jellyfish aggregations during the use of explosive torpedoes (Section 5.3.3.2, Explosive Torpedoes).

The only in-water explosions in the Key West Range Complex, where ESA-listed corals are known to occur, would result from explosive buoys, sonobuoys, torpedoes, and medium- and large-caliber projectiles detonating at or near the surface. Due to the mitigation described above, in addition to the fact that most of these activities would occur more than 12 NM from shore, the probability of shallow-water corals being exposed to detonation effects is low. Exposure would result only if explosions inadvertently occurred near unmapped shallow-water coral reefs, other substrate potentially supporting shallow-water corals, or deeper (i.e., greater than 30 m) hard substrate supporting mesophotic coral species. Although unlikely, there is a small potential for exposure. Pursuant to the ESA, the use of explosives during testing activities as described under Alternative 1 may affect ESA-listed coral species and designated critical habitat. The Navy has consulted with the NMFS, as required by section 7(a)(2) of the ESA in that regard.

3.4.3.2.2.2 Impacts from Explosives Under Alternative 2

<u>Impacts from Explosives Under Alternative 2 for Training Activities</u>

The locations of training activities using explosives on or near the bottom would be the same under Alternatives 1 and 2. The total area affected for all training activities combined over a 5-year period would decrease by less than 1 acre under Alternative 2 (see Table F-25, Potential Impact from Explosives On or Near the Bottom for Training Activities Under Alternatives 1 and 2 Over Five Years, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis) and, therefore, the potential impacts would be similar between the two alternatives. Refer to Section 3.4.3.2.2.1 (Impacts from Explosives Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.2.2.1 (Impacts from Explosives Under Alternative 1), the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks. The mitigation will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including several areas inhabited by ESA-listed coral species. In addition, procedural mitigations include the requirement to avoid jellyfish aggregations during sinking exercises (Section 5.3.3.6, Sinking Exercises) and ship shock trials (Section 5.3.3.11, Ship Shock Trials).

Due to the mitigation described above, the probability of shallow-water corals being exposed to detonation effects is low. Explosions on or over soft bottom up-current from shallow-water coral reefs could kill or injure some coral larvae that could have otherwise settled on suitable habitat down-current. However, this situation is unlikely considering most water-based training areas in the Key West OPAREA do not intersect shallow-water coral reefs. Exposure in the context of shock wave impacts would occur only if explosions inadvertently occurred near unmapped shallow-water coral reefs or other substrate potentially supporting shallow-water corals, including hard substrate areas up to 90 m deep. Although such a scenario is unlikely, there is a small potential for exposure. Pursuant to the ESA, the use of explosives during training activities as described under Alternative 2 may affect ESA-listed coral species and critical habitat.

Impacts from Explosives Under Alternative 2 for Testing Activities

The locations of testing activities using explosives on or near the bottom would be the same under Alternatives 1 and 2. The total area affected for all testing activities combined over a 5-year period would increase by approximately 17 acres, including about 12 acres in the Virginia Capes Range Complex and 5 acres in the Naval Surface Warfare Center, Panama City Testing Range (see Table F-26, Potential Impact from Explosives On or Near the Bottom for Testing Activities Under Alternatives 1 and 2 Over Five Years, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). The area of hard substrate potentially impacted would increase by less than 0.01 percent in each of these areas. The increased area of bottom habitat affected would not result in substantive changes to the potential for or the types of impacts on invertebrates. Refer to Section 3.4.3.2.2.1 (Impacts from Explosives Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.2.2.1 (Impacts from Explosives under Alternative 1), the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks. The mitigation will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including several areas inhabited by ESA-listed coral species. In addition, procedural mitigations include the requirement to avoid jellyfish aggregations during the use of explosive torpedoes (Section 5.3.3.2, Explosive Torpedoes).

The only in-water explosions in the Key West Range Complex, where ESA-listed corals are known to occur, would result from explosive buoys, sonobuoys, torpedoes, and medium- and large-caliber projectiles detonating at or near the surface. Due to the mitigation described above, in addition to the fact that most of these activities occur more than 12 NM from shore, the probability of shallow-water corals being exposed to detonation effects is low. Exposure would occur only if explosions inadvertently occurred near unmapped shallow-water coral reefs or other substrate potentially supporting shallow-water corals, including hard substrate areas to 90 m deep. Although unlikely, there is a small potential for exposure. Pursuant to the ESA, the use of explosives during testing activities as described under Alternative 2 may affect ESA-listed coral species and designated critical habitat.

3.4.3.2.2.3 Impacts from Explosives Under the No Action Alternative

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

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

3.4.3.3 Energy Stressors

This section analyzes the potential impacts of the various types of energy stressors that can occur during training and testing activities within the Study Area. This section includes analysis of the potential impacts from: (1) in-water electromagnetic devices, (2) in-air electromagnetic devices, and (3) high-energy lasers. Aspects of energy stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.2 (Conceptual Framework for Assessing Effects from Energy-Producing Activities).

3.4.3.3.1 Impacts from In-Water Electromagnetic Devices

Several different types of electromagnetic devices are used during training and testing activities. Information on the types of activities that use in-water electromagnetic devices is provided in Appendix B (Activity Stressor Matrices).

Little information is available regarding marine invertebrates' susceptibility to electromagnetic fields. Magnetic fields are not known to control spawning or larval settlement in any invertebrate species. Existing information suggests sensitivity to electric and magnetic fields in at least three marine invertebrate phyla: Mollusca, Arthropoda, and Echinodermata (Bureau of Ocean Energy Management, 2011; Lohmann et al., 1995; Lohmann & Lohmann, 2006). A possible magnetic sense has been suggested in jellyfish as well, although this has not been demonstrated experimentally (Fossette et al., 2015). Much of the available information on magnetic field sensitivity of marine invertebrates pertains to crustaceans. For example, a magnetic compass sense has been demonstrated in the spiny lobster (Ernst & Lohmann, 2018; Lohmann et al., 1995; Lohmann & Lohmann, 2006), and researchers suggest subtle behavioral response to magnetic fields of about 1 millitesla (1,000 microtesla) in the Dungeness crab and American lobster (Woodruff et al., 2013). A review of potential effects of undersea power cables on marine species provides a summary of numerous studies of the sensitivity of various invertebrate species to electric and magnetic fields (Bureau of Ocean Energy Management, 2011). Electric field sensitivity is reported in the summary for only two freshwater crayfish species, while magnetic field sensitivity is reported for multiple marine invertebrate species, including molluscs, crustaceans, and echinoderms. Sensitivity thresholds range from 300 to 30,000 microtesla, depending on the species. Most responses consisted of behavioral changes, although non-lethal physiological effects were noted in two sea urchin species in a 30,000 microtesla field (embryo development) and a marine mussel exposed to 300 to 700 microtesla field strength (cellular processes). Marine invertebrate community structure was not affected by placement of energized underwater power cables with field strengths of 73 to 100 microtesla (Love et al., 2016). Effects to eggs of the sea urchin *Paracentrotus lividus* and to brine shrimp (*Artemia* spp.) cysts have been reported at relatively high magnetic field strengths (750 to 25,000 microtesla) (Ravera et al., 2006; Shckorbatov et al., 2010).The magnetic field generated by the Organic Airborne and Surface Influence Sweep (a typical electromagnetic device used in Navy training and testing) is about 2,300 microtesla at the source. Field strength drops quickly with distance from the source, decreasing to 50 microtesla at 4 m, 5 microtesla at 24 m, and 0.2 microtesla at 200 m from the source. Therefore, temporary disruption of navigation and directional orientation is the primary impact considered in association with magnetic fields.

Studies of the effects of low-voltage direct electrical currents in proximity to marine invertebrates suggest a beneficial impact to at least some species at appropriate current strength. American oysters (*Crassostrea virginica*) and various stony and soft corals occurring on substrates exposed to low-voltage currents (between approximately 10 and 1,000 microamperes) showed increased growth rates and survival (Arifin et al., 2012; Goreau, 2014; Jompa et al., 2012; Shorr et al., 2012). It is theorized that the benefits may result from a combination of more efficient uptake of calcium and other structure-building minerals from the surrounding seawater, increased cellular energy production, and increased pH near the electrical currents. The beneficial effects were noted in a specific range of current strength; higher or lower currents resulted in either no observable effects or adverse effects. The moderate voltage and current associated with the Organic Airborne and Surface Influence Sweep are not expected to result in adverse effects to invertebrates. In addition, due to the short-term, transient nature of electromagnetic device use, there would be no beneficial effects associated with small induced electrical currents in structures colonized by invertebrates.

3.4.3.3.1.1 Impacts from In-Water Electromagnetic Devices Under Alternative 1

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

As indicated in Section 3.0.3.3.3.1 (In-Water Electromagnetic Devices), under Alternative 1, training activities involving in-water electromagnetic devices would occur in the Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico Range Complexes. A small number of activities could also occur in any of 13 inshore water locations (Table 3.0-15, Number and Location of Activities in Inshore Waters Including In-Water Electromagnetic Devices).

The impact of electromagnetic devices to marine invertebrates would depend upon the sensory capabilities of a species and the life functions that its magnetic or electric sensory systems support (Bureau of Ocean Energy Management, 2011). The primary potential effect would be temporary directional disorientation for individuals encountering a human-produced magnetic field. For example, an individual could be confused or change its movement direction while exposed to a field. However, a limited number of studies suggest other effects, such as changes in embryo development, are possible within relatively strong fields for an extended time (10 to 150 minutes). Electromagnetic devices used in Alternative 1 would only affect marine invertebrates located within a few feet of the source. In addition, most electromagnetic devices are mobile and would produce detectable magnetic fields for only a short time at any given location. Further, due to the exponential drop in field strength with distance and the fact that electromagnetic devices are operated in the water column away from the bottom, it is unlikely that benthic invertebrates such as lobsters and crabs would be affected. For example, operation of the Organic Airborne and Surface Influence Sweep in 13 ft. water depth would produce field strength at the bottom that is an order of magnitude lower than any field strength associated with behavioral or physiological effects in the available study reports. Therefore, exposed species would be those typically found in the water column such as jellyfish, squid, and zooplankton, and mostly at night when squid and zooplankton have migrated up in the water column. Although a small number of invertebrates would be exposed to electromagnetic fields, exposure is not expected to yield any lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

In-water electromagnetic devices would not be used in the Key West Range Complex and would therefore not expose ESA-listed coral species to electromagnetic fields. There is no overlap of electromagnetic device use in the Key West Range Complex with designated critical habitat for elkhorn and staghorn coral. Therefore, electromagnetic devices would not affect elkhorn and staghorn coral critical habitat. Pursuant to the ESA, the use of in-water electromagnetic devices during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

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

As indicated in Section 3.0.3.3.3.1 (In-Water Electromagnetic Devices), under Alternative 1, testing activities involving in-water electromagnetic devices would occur within the Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico Range Complexes. In addition, activities would occur at the Naval Surface Warfare Center, Panama City Testing Range, South Florida Ocean Measurement Facility Testing Range, and one inshore water location (Little Creek Virginia).

The impact of electromagnetic devices to marine invertebrates would depend upon the sensory capabilities of a species and the life functions that it's magnetic or electric sensory systems support (Bureau of Ocean Energy Management, 2011). The primary potential effect would be temporary directional disorientation for individuals encountering a human-produced magnetic field. For example, an individual could be confused or change its movement direction while exposed to a field. However, a limited number of studies suggest other effects such as changes in embryo development are possible within relatively strong fields for an extended time (10 to 150 minutes). Electromagnetic devices used in Alternative 1 would only affect marine invertebrates located within a few feet of the source. In addition, most electromagnetic devices are mobile and would produce detectable magnetic fields for only a short time at any given location. Further, due to the exponential drop in field strength with distance and the fact that electromagnetic devices are operated in the water column away from the bottom, it is unlikely that benthic invertebrates such as lobsters and crabs would be affected. For example, operation of the Organic Airborne and Surface Influence Sweep in 13 ft. water depth would produce field strength at the bottom that is an order of magnitude lower than any field strength associated with behavioral or physiological effects in the available study reports. Therefore, exposed species would be those typically found in the water column such as jellyfish, squid, and zooplankton, and mostly at night when squid and zooplankton have migrated up in the water column. Although a small number of invertebrates would be exposed to electromagnetic fields, exposure is not expected to yield any lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

ESA-listed coral species in the South Florida Ocean Measurement Facility Testing Range would have the potential to be exposed to electromagnetic fields. However, this exposure from predominantly mobile sources is considered unlikely because the coral is distributed as a narrow band that is avoided as a navigation hazard during testing activities. The electromagnetic devices used to trigger mines during testing activities are towed by helicopters near the surface and away from potential obstructions. Portions of the range are exempt from designation of elkhorn and staghorn coral critical habitat. In addition, electromagnetic devices would not affect important characteristics of critical habitat. The available research on the effects of electromagnetic energy on invertebrates suggests there would be no meaningful impact on invertebrates, including ESA-listed coral species, even in the highly unlikely event of exposure for a prolonged duration. Pursuant to the ESA, the use of in-water electromagnetic devices during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.3.1.2 Impacts from In-Water Electromagnetic Devices Under Alternative 2

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

The locations, number of events, and potential effects associated with in-water electromagnetic devices would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.3.1.1 (Impacts from In-Water Electromagnetic Devices Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.3.1.1 (Impacts from In-Water Electromagnetic Devices Under Alternative 1), pursuant to the ESA, the use of in-water electromagnetic devices during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

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

The locations, number of events, and potential effects associated with in-water electromagnetic devices would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.3.1.1 (Impacts from In-Water Electromagnetic Devices Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.3.1.1 (Impacts from In-Water Electromagnetic Devices Under Alternative 1), pursuant to the ESA, the use of in-water electromagnetic devices during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.3.1.3 Impacts from In-Water Electromagnetic Devices Under the No Action Alternative

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

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

3.4.3.3.2 Impacts from In-Air Electromagnetic Devices

In-air electromagnetic devices are not applicable to invertebrates because of the lack of transmission of electromagnetic radiation across the air/water interface and will not be analyzed further in this section.

3.4.3.3.3 Impacts from High-Energy Lasers

This section analyzes the potential impacts of high-energy lasers on invertebrates. As discussed in Section 3.0.3.3.3.3 (Lasers), high-energy laser weapons are designed to disable surface targets, rendering them immobile. The primary concern is the potential for an invertebrate to be struck with the laser beam at or near the water's surface, where extended exposure could result in injury or death.

Marine invertebrates could be exposed to the laser only if the beam misses the target. Should the laser strike the sea surface, individual invertebrates at or near the surface, such as jellyfish, floating eggs, and larvae, could potentially be exposed. The potential for exposure to a high-energy laser beam decreases rapidly as water depth increases and with time of day, as many zooplankton species migrate away from the surface during the day. Most marine invertebrates are not susceptible to laser exposure because they occur beneath the sea surface.

3.4.3.3.3.1 Impacts from High-Energy Lasers Under Alternative 1

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

As indicated in Section 3.0.3.3.3.3 (Lasers), under Alternative 1, training activities involving high-energy lasers would occur within the Virginia Capes and Jacksonville Range Complexes. Invertebrates that do not occur at or near the sea surface would not be exposed due to the attenuation of laser energy with depth. Surface invertebrates such as squid, jellyfish, and zooplankton (which may include invertebrate larvae) exposed to high-energy lasers could be injured or killed, but the number of individuals potentially impacted would be low based on the relatively low number of events, very localized potential impact area of the laser beam, and the temporary duration (seconds) of potential impact. Activities involving high-energy lasers are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level because of the relatively small number of individuals that could be impacted.

Training activities that include high-energy lasers would not be conducted in areas where ESA-listed coral species or designated critical habitat occur. Pursuant to the ESA, the use of high-energy lasers during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

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

As indicated in Section 3.0.3.3.3.3 (Lasers), under Alternative 1, testing activities involving high-energy lasers would occur within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes. In addition, activities would occur within the Naval Undersea Warfare Center, Newport Testing Range, Naval Surface Warfare Center, Panama City Testing Range, and South Florida Ocean Measurement Facility Testing Range. Most activities would occur in the Virginia Capes Range Complex.

Invertebrates that do not occur at or near the sea surface would not be exposed due to the attenuation of laser energy with depth. Surface invertebrates such as squid, jellyfish, and zooplankton (which may include invertebrate larvae) exposed to high-energy lasers could be injured or killed, but the number of individuals potentially impacted would be low based on the relatively low number of events, very localized potential impact area of the laser beam, and the temporary duration (seconds) of potential impact. Activities involving high-energy lasers are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level because of the relatively small number of individuals that could be impacted.

ESA-listed coral species occur in the Key West Range Complex and South Florida Ocean Measurement Facility Testing Range. High-energy lasers would not impact adult corals because the laser intensity would attenuate in the water column and would likely be undetectable to benthic species. Potential for impacts would be associated with eggs or larvae of ESA-listed coral species that could occur at the surface. Any eggs or larvae exposed could be injured or killed. As discussed above for invertebrates in general, the probability of impacting coral eggs or larvae is low based on the relatively low number of events, very localized potential impact area of the laser beam, and the temporary duration (seconds) of potential exposure. High-energy lasers would not affect important characteristics of designated elkhorn and staghorn critical habitat. Pursuant to the ESA, the use of high-energy lasers during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.3.3.2 Impacts from High-Energy Lasers Under Alternative 2

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

The locations, number of events, and potential effects associated with high-energy lasers would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.3.3.1 (Impacts from High-Energy Lasers Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.3.1.1 (In-Water Electromagnetic Devices Under Alternative 1), pursuant to the ESA, the use of high-energy lasers during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

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

The locations, number of events, and potential effects associated with high-energy lasers would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.3.3.1 (Impacts from High-Energy Lasers Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.3.3.1 (Impacts from High-Energy Lasers Under Alternative 1), pursuant to the ESA, the use of high-energy lasers during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.3.3.3 Impacts from High-Energy Lasers Under the No Action Alternative

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

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. High-energy laser use is not a part of ongoing Navy activities in the Study Area and this energy stressor would not be introduced into the marine environment under the No Action Alternative. Therefore, no change in baseline conditions of the existing environment would occur.

3.4.3.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and strike stressors that could result from Navy training and testing activities within the Study Area. For a list of locations and numbers of activities that may cause physical disturbance and strikes refer to Section 3.0.3.3.4 (Physical Disturbance and Strike Stressors). Aspects of physical disturbance and strike stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.3 (Conceptual Framework for Assessing Effects from Physical Disturbance or Strike). The physical disturbance and strike stressors that may impact marine invertebrates include: (1) vessels and in-water devices, (2) military expended materials, (3) seafloor devices, and (4) pile driving.

Most marine invertebrate populations extend across wide areas containing hundreds or thousands of discrete patches of suitable habitat. Sessile invertebrate populations may be connected by complex currents that carry adults and young from place to place. Impacts to such widespread populations are difficult to quantitatively evaluate in terms of Navy training and testing activities that occur intermittently and in relatively small patches in the Study Area. Invertebrate habitats generally cover enormous areas (Section 3.5, Habitats) and, in this context, a physical strike or disturbance would impact individual organisms directly or indirectly, but not to the extent that viability of populations of common species would be impacted. While the potential for overlap between Navy activities and invertebrates is reduced for those species living in rare habitats, if overlap does occur, any potential impacts would be amplified for those invertebrate species or taxa with limited spatial extent. Examples of such organisms include shallow-water, mesophotic, and deep-water corals and sponges, which are mostly restricted to hard bottom habitat. Shallow-water coral reefs and some other areas of hard substrate are protected to the extent they are included in current mitigation measures. With few exceptions, activities involving vessels and in-water devices are not intended to contact the bottom due to potential damage to equipment and the resulting safety risks for vessel personnel. The potential for strike impact and disturbance of benthic or habitat-forming marine invertebrates would result from amphibious activities, bottom-crawling unmanned underwater vehicles, military expended materials, seafloor devices, and pile driving. For environmental and safety reasons, amphibious landings and other nearshore activities would avoid areas where corals are known to occur.

With the exception of habitat-forming benthic taxa (e.g., corals, sea pens, sponges), most small invertebrate populations recover quickly from non-extractive disturbance. Many large invertebrates, such as crabs, shrimps, and clams, undergo massive disturbance during commercial and recreational harvests, storms, or beach restoration activities. Invertebrates that occur in the high-energy surf zone are typically resilient to dynamic processes of sediment erosion and accretion, although some community effects may occur due to rapid and relatively large-scale changes such as those associated with beach renourishment projects (U.S. Army Corps of Engineers, 2001).

Biogenic habitats such as shallow coral reefs, deep-water coral, and sponge communities may take decades to regrow following a strike or disturbance (Jennings & Kaiser, 1998; Precht et al., 2001). However, bottom-disturbing activities are not conducted on mapped coral reefs or live hard bottom. In soft bottom areas, recovery of benthic invertebrate populations after substantial human disturbance depends on factors such as size of the area disturbed, bottom topography, hydrodynamics of the affected area, seasonality of the disturbance, and the size and typical growth rate of affected species. Most studies of the effects of beach sand nourishment projects (which is a proxy for impacts due to amphibious landings) have reported initial declines in benthic invertebrate populations due to burial and increased turbidity (which may affect filter-feeding capability), but subsequent recovery over time scales of weeks to years (Posey & Alphin, 2002; U.S. Army Corps of Engineers, 2001, 2012; Wilber et al., 2009). Recovery is typically greatest at nourishment sites when there is a close match in grain size between the existing and supplied sediment. However, species composition may be altered in the recolonized area, and overall invertebrate biomass may not recover for many years. Researchers found that trawling off the California coast resulted in no statistical difference in the abundance of sessile or mobile benthic invertebrates (Lindholm et al., 2013). However, repeated and intense bottom fishing disturbance can result in a shift from communities dominated by relatively high-biomass individuals towards dominance by high abundance of small-sized organism (Kaiser et al., 2002). If activities are repeated at the same site, the benthic invertebrate community composition could be altered over time (years), especially for sessile invertebrates (e.g., coral). Some bottom-disturbing activities, such as mine countermeasures and neutralization training and testing, precision anchoring, and placement of the Elevated Causeway System, may occur in the same locations or near the same locations yearly.

3.4.3.4.1 Impacts from Vessels and In-Water Devices

Vessels

The majority of the training and testing activities under all the alternatives involve vessels. For a discussion of the types of activities that use vessels and where they are used, refer to Appendix B (Activity Stressor Matrices). See Table 3.0-17 (Representative Vessel Types, Lengths, and Speeds) for a representative list of Navy vessel types, lengths, and speeds. Figure 3.0-11 (Relative Distribution of U.S. Navy Vessel Traffic) depicts the relative intensity of Navy vessel use in the Study Area.

Vessels could impact adults and other life stages of marine invertebrates by directly striking organisms, or by disturbing the water column or sediments (Bishop, 2008). Species that occur at or near the surface (e.g., jellyfish, squid) would potentially be exposed to direct vessel strikes. Exposure to propeller-generated turbulence was found to result in mortality in a zooplankton species (the copepod *Acartia tonsa*) located near the surface (Bickel et al., 2011). However, many pelagic invertebrates such as squid and zooplankton move away from the surface during the day, reducing potential exposures during daytime vessel operations. Many vessel hulls have a hydrodynamic shape, and pelagic marine invertebrates are therefore generally disturbed, rather than struck, as the water flows around a vessel. Zooplankton are ubiquitous in the water column and typically experience high mortality rates.

In addition, vessel hull strikes and propeller cavitation and turbulence could displace, damage, injure, or kill invertebrate eggs and larvae in the upper portion of the water column throughout the Study Area. For example, turbulent water was found to decrease successful fertilization and resulted in abnormal development and low survival in eggs of the broadcast spawning purple sea urchin (*Strongylocentrotus purpuratus*) (Mead & Denny, 1995). In some areas, vessels could transit through water containing coral gametes, eggs, embryonic stages, or planula larvae of broadcast spawning species. These life stages would be most likely to occur in the Caribbean Sea, Gulf of Mexico, and Southeast U.S. Continental Shelf Large Marine Ecosystems. Eggs of cluster coral (*Acropora millepora*) were found to disintegrate into irregular groups or individual blastomeres when subjected to even very light shearing forces and turbulence (Heyward & Negri, 2012). Such dissociation can be beneficial through creation of more juveniles, but may also cause mortality. Early embryonic development of broadcast spawning coral species has reportedly been affected by handling of captive-reared embryos (Guest et al., 2010). Although the available information indicates that developmental stages of numerous invertebrate species could be physically impacted, broadcast-spawning invertebrates produce very large numbers of eggs and planktonic larvae that typically experience high mortality rates under normal conditions (Nybakken, 1993). Any impacts resulting from Navy vessel operation would be biologically insignificant by comparison.

The average water depth of the OPAREAs in the Study Area is 3,650 ft. Propeller wash (water displaced by propellers used for propulsion) of even the deepest draft vessels operated over the continental shelf is likely indistinguishable from the water motion associated with periodic storm events, and vessel operation in deeper waters beyond the shelf break would not affect the bottom. Therefore, the potential for vessels to disturb invertebrates on or near the bottom would occur mostly during nearshore and inshore training or testing activities, and along dredged navigation channels. Invertebrates on or near the bottom in such relatively shallow areas could be affected by sediment disturbance or direct strike during amphibious landings. Few sources of information are available on the impact of non-lethal chronic vessel disturbance to marine invertebrates. One study of seagrass-associated marine invertebrates, such as amphipods and polychaetes, found that chronic disturbance from vessel wakes resulted in the long-term displacement of some marine invertebrates from the impacted shallow-water area (Bishop, 2008). However, invertebrates that typically occur in areas associated with nearshore or inshore activities, such as shorelines, are highly resilient to vessel disturbance. They are regularly disturbed by natural processes such as high-energy waves and longshore currents, and generally recover quickly. Potential exceptions include sessile or encrusting invertebrates (primarily oysters) that occur along sheltered shorelines that are subject to a high frequency of boat propeller- or wake-induced erosion (Grizzle et al., 2002; Zabawa & Ostrom, 1980). Increased erosion of shoreline banks or suspension of bottom sediments may cause turbidity that settles on oysters and causes the oysters to ingest more non-food particles. The results of a small number of studies suggest that the wave energy resulting from boat wakes produced in relatively narrow water bodies may affect oyster occurrence, and studies of shallow freshwater areas found that waves generated from small boats caused about 10 percent of benthic invertebrates (e.g., amphipods) to become suspended in the water column where they presumably would be more vulnerable to predation (Bilkovic et al., 2017).

Non-amphibious vessels avoid contact with the bottom in order to prevent damage to the vessels and benthic habitat that supports encrusting organisms. The encrusting organisms (e.g., hard corals) living on hard substrate in the ocean are exposed to strong currents under natural conditions and would not likely be affected by propeller wash. Many activities occur in offshore areas and, therefore, would be unlikely to affect benthic invertebrates, although small-caliber gunnery exercises, blank firing, and smoke grenade use may occur proximate to Navy homeports in Jacksonville, Florida and Norfolk, Virginia. Many Navy vessel movements in nearshore waters are concentrated in established channels and ports or predictable transit corridors, and shallow-water vessels typically operate in defined boat lanes with sufficient depths to avoid propeller or hull strikes on the bottom. Exceptions include small vessel training in navigable inshore waters, where propeller movement may disturb sediments and associated benthic invertebrate communities in sheltered areas.

Activities that occur in inshore waters can last from a few hours up to 12 hours of daily movement per vessel per activity, and can involve speeds greater than 10 knots. Vessel movements in the inshore waters of the Study Area occur on a more regular basis than the offshore activities, and generally occur in more confined waterways (primarily in the Lower Chesapeake Bay and James River). Information on the number and location of activities using vessels, as well as the number of hours of operation for inshore waters, is provided in Section 3.0.3.3.4.1 (Vessels and In-Water Devices).

The only source of shallow-water vessel movement in the Study Area with known direct impacts to benthic invertebrates is amphibious landings, which are conducted in the Navy Cherry Point and Jacksonville Range Complexes (Appendix A, Navy Activity Descriptions). Amphibious vessels would contact the bottom in the surf zone during amphibious assault and amphibious raid operations. Benthic invertebrates of the surf zone, such as mole crabs, clams, and polychaete worms, within the disturbed area could be displaced, injured, or killed during amphibious operations. Burrowing species such as ghost shrimp are present on many beaches, and individuals in relatively shallow burrows located just above harder sand layers could be injured or killed if amphibious vessels compress the sand above them. Passage of amphibious vessels could cause some elevated turbidity in the nearshore zone seaward of the surf zone. However, the sediment along landing beaches is constantly being reworked by nearshore wave energy and, to a lesser extent (although more frequently than disturbance caused by amphibious landings), storm events. Benthic invertebrates inhabiting these areas are adapted to a naturally disturbed environment and are expected to rapidly re-colonize similarly disturbed areas by immigration and larval recruitment. Studies indicate that benthic communities of high-energy sandy beaches recover relatively quickly (typically within 2 to 7 months) following beach nourishment. Researchers found that the macrobenthic (visible organisms on the bottom) community required between 7 and 16 days to recover following excavation and removal of sand from a 200 m^2 quadrant from the intertidal zone of a sandy beach (Schoeman et al., 2000). The number of invertebrates impacted during amphibious landings would be small compared to the number affected during activities such as beach nourishment. The impacts of amphibious vehicle operations on benthic communities would therefore likely be minor, short term, and local.

Other than organisms occurring at amphibious landing sites, invertebrates that occur on the bottom, including shallow-water corals, organisms associated with hard bottom, and deep-water corals, are not likely to be exposed to vessel strikes. Propeller movement has the potential to disrupt sediments that could affect shallow-water corals and hard bottom communities. However, shallow-water corals do not occur along the shoreline adjacent to the Navy Cherry Point or Jacksonville Range Complexes, where amphibious landings are conducted. Therefore, corals would not likely be affected by vessel movements.

In-Water Devices

Some of the training and testing activities under both action alternatives involve the use of in-water devices such as remotely operated vehicles, unmanned surface vehicles, unmanned underwater vehicles, motorized autonomous targets, and towed devices. For a discussion of the types of activities that use in-water devices, see Appendix B (Activity Stressor Matrices). See Table 3.0-21 (Representative Types, Sizes, and Speeds of In-Water Devices) for the types, sizes, and speeds of representative Navy in-water devices used in the Study Area.

In-water devices can operate from the water's surface to the benthic zone. The devices could potentially impact marine invertebrates by directly striking organisms or by disturbing the water column. As discussed for vessel use, most invertebrates in the water column would be disturbed, rather than struck, as water flows around a device due to the hydrodynamic shape. In addition, in-water devices are smaller than most Navy vessels, decreasing the surface area in which invertebrates could be struck. The potential for direct strike is reduced for some types of devices because they are operated at relatively low speeds (e.g., unmanned underwater vehicles, which are typically operated at speeds of 1 to 15 knots). Unmanned surface vehicles are operated at the greatest speeds (up to 50 knots or more) and therefore have greater potential to strike invertebrates. However, relatively few invertebrates occur at the surface and consist mostly of squid, jellyfish, and zooplankton. Squid and many zooplankton species move away from the surface during the day (Nybakken, 1993), when unmanned surface vehicles are typically operated. In-water devices do not normally collide with invertebrates on the bottom because the devices are operated in relatively deep water and contact with the bottom is avoided. Devices operated very near the bottom could potentially disturb sediments and associated invertebrates through propeller wash. However, such disturbance would be infrequent and would affect a small area, and disturbed areas would be quickly reoccupied by benthic invertebrates.

As discussed for vessels, zooplankton and invertebrate eggs and larvae could be displaced, damaged, injured, or killed by propeller wash or turbulence resulting from water flow around in-water devices. Effects due to turbulence would generally increase with increasing speed of the device. Many zooplankton species migrate away from the surface during the day, when Navy training and testing typically are conducted, decreasing the potential for impacts in the upper portions of the water column. The number of individuals affected would be small in comparison to overall populations, and the affected species generally exhibit rapid growth and recovery rates.

3.4.3.4.1.1 Impacts from Vessels and In-Water Devices Under Alternative 1

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

The numbers and locations of activities that include vessels are shown in Table 3.0-18 (Number and Location of Activities Including Vessels) and Table 3.0-19 (Number and Location of Activities in Inshore Waters Including Vessels), and the numbers and locations of activities that include in-water devices are shown in Table 3.0-22 (Number and Location of Activities Including In-Water Devices) and Table 3.0-23 (Number and Location of Activities in Inshore Waters Including In-Water Devices). The majority of Navy training activities include vessels, while a lower number of activities include in-water devices. As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), vessel operation would be widely dispersed throughout the Study Area, but would be more concentrated near ports, naval installations, and range complexes. Most vessel use would occur in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. In particular, Navy training vessel traffic would be concentrated in the Northeast U.S. Continental Shelf Large Marine Ecosystem near Naval Station Norfolk in Norfolk, Virginia, and in the Southeast U.S. Continental Shelf Large Marine Ecosystem near Naval Station Mayport in Jacksonville, Florida. Vessel operation in inshore waters would occur in numerous areas but would be concentrated in the Lower Chesapeake Bay and James River. Amphibious landings would be restricted to designated beaches. There is no seasonal differentiation in Navy vessel use. Large vessel movement primarily occurs within the U.S. Exclusive Economic Zone, with the majority of the traffic moving between Naval Stations Norfolk and Mayport.

Similar to vessel operation, activities involving in-water devices could be widely dispersed throughout the Study Area, but would be more concentrated near naval ports, piers, and ranges. Training activities would occur in the Northeast and Southeast U.S. Continental Shelf and Gulf of Mexico Large Marine Ecosystems, as well as the Gulf Stream Open Ocean Area. However, most events would occur within the Virginia Capes Range Complex and Jacksonville Range Complex.

As discussed in Section 3.4.3.4.1 (Impacts from Vessels and In-Water Devices), invertebrates located at or near the surface could be struck or disturbed by vessels, and invertebrates throughout the water column could be similarly affected by in-water devices. There would be a higher likelihood of vessel and in-water device strikes over the continental shelf than in the open ocean portions of the Study Area because of the concentration of activities and comparatively higher abundances of invertebrates in areas closer to shore. However, direct strikes would generally be unlikely for most species. Exceptions would include amphibious landings, where vessels contact the bottom and may directly impact invertebrates. Organisms inhabiting these areas are expected to rapidly re-colonize disturbed areas. Other than during amphibious landings, purposeful contact with the bottom by vessels and in-water devices would be avoided. The potential to disturb invertebrates on or near the bottom would occur mostly during vessel nearshore and onshore training activities, and along dredged navigation channels. Invertebrates that typically occur in areas associated with nearshore or onshore activities, such as shorelines, are highly resilient to vessel disturbance. Potential exceptions include sessile invertebrates that occur along sheltered shorelines that are subject to vessel-induced erosion. Propeller wash and turbulent water flow could damage or kill zooplankton and invertebrate gametes, eggs, embryonic stages, or larvae. The potential for erosion-related impacts could be greater during high speed vessel operation, which occurs in numerous inshore waters but would be more concentrated in the Lower Chesapeake Bay, James River, Cooper River, and Narragansett Bay. Overall, the area exposed to vessel and in-water device disturbance would be a very small portion of the surface and water column in the Study Area, and only a small number of individuals would be affected compared to overall abundance. Therefore, the impact of vessels and in-water devices on marine invertebrates would be inconsequential. Activities are not expected to yield any lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Species that do not occur near the surface within the Study Area, including all ESA-listed coral species, would not be exposed to vessel or in-water device strikes. Although some training activities would be conducted in the Key West Range Complex, vessels would 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. There would be no overlap of vessels or in-water devices with designated critical habitat for elkhorn and staghorn coral (Section 3.4.2.2.1.1, Status and Management) because the vessels and devices are not expected to contact the bottom during training activities. Amphibious vehicles are an exception, but elkhorn and staghorn coral critical habitat does not include locations where amphibious vehicles come in contact with the bottom. Therefore, vessels and in-water devices would not affect elkhorn and staghorn coral critical habitat. Pursuant to the ESA, the use of vessels and in-water devices during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

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

The numbers and locations of activities that include vessels are shown in Table 3.0-18 (Number and Location of Activities Including Vessels) and Table 3.0-19 (Number and Location of Activities in Inshore Waters Including Vessels), and the numbers and locations of activities that include in-water devices are shown in Table 3.0-22 (Number and Location of Activities Including In-Water Devices). As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), vessel operation would be widely dispersed throughout the Study Area, but would be more concentrated near ports, naval installations, testing ranges, and range complexes. Vessel movements would occur throughout the Study Area but would be concentrated in the Northeast, Virginia Capes, and Jacksonville Range Complexes. Similarly, as indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), in-water devices would be used throughout the Study Area but would be concentrated in the Virginia Capes and Jacksonville Range Complexes, and the Naval Undersea Warfare Center, Newport Testing Range.

As discussed in Section 3.4.3.4.1 (Impacts from Vessels and In-Water Devices), invertebrates located at or near the surface could be struck or disturbed by vessels, and invertebrates throughout the water column could be similarly affected by in-water devices. There would be a higher likelihood of vessel and in-water device strikes over the continental shelf than in the open ocean portions of the Study Area because of the concentration of activities and the comparatively lower invertebrate abundances in those areas. However, direct strikes would generally be unlikely for most species, particularly for benthic invertebrates due to the absence of amphibious landings. Purposeful contact with the bottom would be avoided. Propeller wash and turbulent water flow could damage or kill zooplankton and invertebrate gametes, eggs, embryonic stages, or larvae. Overall, the area potentially exposed to vessel and in-water device disturbance is a very small portion of the surface and water column in the Study Area, and only a small number of individuals would be affected compared to overall abundance. The impact of vessels and in-water devices on marine invertebrates would be inconsequential. Activities are not expected to yield any lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Species that do not occur near the surface within the Study Area, including all ESA-listed coral species, would not be exposed to vessel or in-water device strikes. Although some activities would be conducted in the Key West Range Complex and South Florida Ocean Measurement Facility Testing Range, vessels would 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. There would be no overlap of vessels or in-water devices with designated critical habitat for elkhorn and staghorn coral (Section 3.4.2.2.1.1, Status and Management) because the vessels and devices do not contact the bottom. Amphibious landings are not associated with testing activities. Pursuant to the ESA, the use of vessels and in-water devices during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.4.1.2 Impacts from Vessels and In-Water Devices Under Alternative 2

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

Under Alternative 2, potential impacts to invertebrates resulting from vessels and in-water devices associated with training activities would be similar to those discussed for activities under Alternative 1. There would be a very small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.4.1.1 (Impacts from Vessels and In-Water Devices Under Alternative 1) for a discussion of potential impacts.

As discussed in Section 3.4.3.4.1.1 (Impacts from Vessels and In-Water Devices Under Alternative 1), pursuant to the ESA, the use of vessels and in-water devices during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

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

Under Alternative 2, potential impacts to invertebrates resulting from vessels and in-water devices associated with testing activities would be similar to those discussed for activities under Alternative 1. There would be a very small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.4.1.1 (Impacts from Vessels and In-Water Devices Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.4.1.1 (Impacts from Vessels and In-Water Devices Under Alternative 1), pursuant to the ESA, the use of vessels and in-water devices during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.4.1.3 Impacts from Vessels and In-Water Devices Under the No Action Alternative

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

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

3.4.3.4.2 Impacts from Aircraft and Aerial Targets

Impacts from aircraft and aerial targets are not applicable because marine invertebrates do not occur in airborne environments and will not be analyzed further in this section. Refer to Section 3.4.3.4.3 (Impacts from Military Expended Materials) for potential disturbance from fragments of aircraft and aerial targets.

3.4.3.4.3 Impacts from Military Expended Materials

This section analyzes the strike potential to marine invertebrates 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. For a discussion of the types of activities that use military expended materials, refer to Appendix B (Activity Stressor Matrices). For information on where they are used and how many exercises would occur under each alternative, see Appendix F (Military Expended Materials and Direct Strike Impact Analysis) and Section 3.0.3.3.4.2 (Military Expended Materials). Analysis of all potential impacts of military expended materials (disturbance, strike, shading, and abrasion) on invertebrates, including ESA-listed coral species and designated critical habitat (elkhorn and staghorn coral), is included in this section. Potential impacts of military expended materials resulting from entanglement and ingestion are discussed in Sections 3.4.3.5 (Entanglement Stressors) and Section 3.4.3.6 (Ingestion Stressors).

Military expended materials are deposited throughout the Study Area. However, the majority of military expended materials are deposited within established range complexes and testing ranges. These areas of higher military expended materials deposition are generally located away from the coastline on the continental shelf and slope and beyond (e.g., abyssal plain).

Physical disturbance or strikes by military expended materials on marine invertebrates is possible at the water's surface, through the water column, and on the bottom. However, disturbance or strike impacts on marine invertebrates by military expended materials falling through the water column are not very likely because military expended materials do not generally sink rapidly enough to cause strike injury. Exposed invertebrates would likely experience only temporary displacement as the object passes by. Therefore, the discussion of military expended materials disturbance and strikes will focus on items at the water's surface and on the bottom.

Potential impacts to invertebrates generally consist of physical trauma, stress or behavioral responses, abrasion, and shading. Military expended materials may injure or kill invertebrates by directly striking individuals, causing breakage (particularly for species with exoskeletons or that build structures), crushing, or other physical trauma. Direct strike may result from the initial impact, or may occur after items fall through the water column and settle onto invertebrates or are moved along the bottom by water currents or gravity. Expended items may also bury or smother organisms although, depending on the size of the expended item relative to the animal, some mobile invertebrates may be able to move or dig out from underneath an item. In addition to physical strike, military expended materials may disturb individuals and cause them to change locations, behaviors, or activities. Disturbance could therefore result in impacts such as briefly increased energy expenditure, decreased feeding, and increased susceptibility to predation. Expended items could also cause increased turbidity that could affect filter-feeding species, although such impacts are likely to be localized and temporary. Expended items that come to rest on or near corals could cause abrasion or shading (in the case of corals that host symbiotic algae) that reduces photosynthesis in the algae, although these effects are unlikely based on the mitigation measures in place for shallow-water coral reefs where symbiotic algae are present. Abrasion refers to scraping or wearing down of a supporting structure or hard body part (e.g., coral skeleton, shell) through repeated impact to the same individual or structure. Abrasion would generally be associated with military expended materials such as flexible materials (e.g., wires or cords) that become fixed in a location for some time but that are moved repeatedly over sessile invertebrates by water currents.

Military expended materials that impact the water surface could directly strike zooplankton, the gametes, embryos, and larvae of various invertebrate species (including ESA-listed corals), and a small number of adult invertebrates (e.g., squid, jellyfish, swimming crabs). However, many zooplankton and squid are absent from the surface water column during the day when most training and testing activities occur. Inert military expended materials also have the potential to impact the water and produce a large impulse which could disturb nearby invertebrates. Potential impacts to invertebrates resulting from impulsive sound and shock waves are discussed in Section 3.4.3.1 (Acoustic Stressors) and

Section 3.4.3.2 (Explosive Stressors). In addition to direct strike of invertebrates and production of impulsive sound, surface water impacts could affect physical properties of the surrounding water (e.g., slight heating or increased dissolved gas concentrations due to turbulent mixing with the atmosphere), potentially affecting the suitability of the affected water mass as habitat for some invertebrate species. However, physical changes to the water column would be localized and temporary, persisting for only a few minutes. Compared to surface waters and offshore areas, a greater number of macroinvertebrates typically occurs on the bottom and closer to shore. Benthic invertebrate taxa, including sponges, cnidarians, worms, bryozoans, molluscs, arthropods, and echinoderms, may occur in areas affected by military expended materials. However, some of the most sensitive benthic species (e.g., corals) are more likely to occur on hard bottom, reefs, and other hard substrates. Shallow-water coral reefs are protected by mitigation measures from most activities that generate military expended materials. Military expended materials that impact the bottom may affect invertebrates by strike (including injury or mortality), disturbance, burial, abrasion, or shading within the footprint of the item (the area of substrate physically covered by the item). Military expended materials may also cause physiological or behavioral reactions to individual invertebrates outside the footprint of the items. After items come to rest on the bottom, continued impacts are possible if the items are mobilized by currents or waves and damage benthic invertebrates as they move. Turbidity may also occur as water flows around deposited items. However, these impacts would generally cease when the military expended materials are incorporated into the seafloor by natural encrustation or burial processes, or become otherwise immobilized.

Sessile marine invertebrates and infauna (organisms attached to the bottom or living in the sediments) are generally more susceptible to military expended material disturbance and strike than benthic species with the ability to move relatively quickly over the bottom. Some susceptible species (e.g., hydroids, sponges, soft corals) have fragile structures and sensitive body parts that could be damaged or covered by military expended materials. Military expended materials could also break hard structures such as coral skeletons and mussel beds. Shallow- and deep-water corals that build complex or fragile structures could be particularly susceptible to breakage or abrasion. Such structures are resistant to physical forces typical of ambient conditions (e.g., water currents), but not as resilient to other types of physical disturbance involving greater force. Decelerators/parachutes would be unlikely to be carried by currents onto reef structures due to the typical offshore locations of use and the sink rate of the items. Expended items may provide new colonization sites for benthic invertebrates. Researchers found that military expended materials in a bombing range became covered by sedentary reef invertebrates over time (Smith & Marx, 2016). However, invertebrate species composition on artificial substrates may differ from that of the surrounding natural community.

Potential impacts to shallow-water corals, invertebrates associated with hard bottom habitat, or deep-water corals present the greatest risk of long-term damage compared with other bottom communities because: (1) many corals and hard bottom invertebrates are sessile, fragile, and particularly vulnerable; (2) many of these organisms grow slowly and could require decades to recover; and (3) military expended materials are likely to remain exposed on hard bottom communities whereas shifting sediment patterns would tend to bury military expended materials in soft bottom communities. The probability of striking deep-water corals or invertebrates located on hard bottom habitat is low, given their low percent cover on suitable habitat (see Section 3.5.2.1.2, Bottom Habitats, for a discussion of hard bottom habitat). For example, deep-water coral was present on less than 5 percent of coral rubble mounds found beyond the shelf break in the Jacksonville Range Complex (U.S. Department of the Navy, 2010).

A few investigations have been conducted to determine the presence and, in some cases, possible impacts of military expended materials on the bottom. The results of multi-year underwater surveys at a military bombing range in the Mariana Archipelago (Pacific Ocean) provide an example of potential impacts resulting from expended munitions. Water areas were not targeted at this range; 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 (Smith & Marx, 2016). Numerous intact bombs and fragments were observed on the bottom. Inert 500-lb. bombs were found to disturb a bottom area of 17 m^2 each, although specific damage to invertebrates, if any, was not described. It may be presumed that invertebrates within this footprint could have been killed, injured, damaged, or displaced. Expended 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. However, the results of several other studies indicate that sessile invertebrate communities growing on artificial substrate such as the expended munitions are often different than those growing on natural substrate (Burt et al., 2009; Macreadie et al., 2011; Perkol-Finkel et al., 2006; Steimle & Zetlin, 2000). A remotely operated vehicle survey of deep portions of the Jacksonville Range Complex reported only two exposed items of military expended materials in about 37,800 m of survey line distance (U.S. Department of the Navy, 2010, 2011). However, it is important to note that the survey was not designed to document military expended materials and these were only the items photographed using still frames. Another extensive remotely operated vehicle survey along the continental shelf break and canyons in the northeast and mid-Atlantic region found marine debris in 81 percent of individual dives, but the items did not include any visible military expended materials (Quattrini et al., 2015). Underwater surveys of bottom areas off the Gulf coast of Florida with a presumably high potential for military expended materials (based on reported obstructions by fishermen) found no items of military origin, suggesting that expended materials may be widely distributed or may become covered by sediments (U.S. Department of the Navy, 2013). In a deep-sea trawl survey of the northern Gulf of Mexico, items of military origin were found (artillery shells and a missile), but were among the least-frequently encountered types of debris (Wei et al., 2012).

Military Expended Materials - Munitions

Military expended materials that are munitions and associated with training activities include small-, medium-, and large-caliber projectiles, bombs, missiles, rockets, and grenades. Fragments of exploded munitions are also included because they can result in impacts on invertebrates that are similar to those associated with smaller intact munitions. Military expended materials associated with testing activities are the same except that there are no grenades. Navy training and testing activities in the Study Area include firing a variety of weapons and using a variety of non-explosive training and testing rounds, including small-, medium-, and large-caliber projectiles. Large-caliber projectiles are primarily used in the open ocean beyond 20 NM from shore. Direct strike from bombs, missiles, and rockets would result in types of impacts similar to those of projectiles. However, they are larger than most projectiles and are likely to produce a greater number of fragments. Bombs, missiles, and rockets are designed to explode within about 3 ft. of the sea surface, where marine invertebrates larger than zooplankton are relatively infrequent.

Military Expended Materials Other Than Munitions

Military expended materials other than munitions associated with training activities include a large number of items such as aerial countermeasures, targets (surface and aerial), mine shapes, ship hulk, decelerators/parachutes, acoustic countermeasures, sonobuoys, and other materials such as torpedo accessories, concrete slugs, marine markers, bathythermographs, endcaps, and pistons. Expended materials associated with testing activities are similar but include some additional items such as explosive sonobuoys and explosive mines. Some expended materials used during training and testing activities, including some types of torpedoes and targets, non-explosive mine shapes, and bottom-placed instruments, are recovered.

Chaff, which consists of aluminum-coated glass fibers, may be transported great distances by the wind, beyond the areas where they are deployed, before contacting the sea surface. These materials contact the sea surface and bottom with very little kinetic energy, and their low buoyant weight makes them an inconsequential strike and abrasion risk. Therefore, chaff is not considered to be a potential strike and disturbance stressor.

During a sinking exercise, aircraft, ship, and submarine crews deliver munitions on a surface target, which is a clean, deactivated ship that is deliberately sunk using multiple weapon systems. Sinking exercises occur in specific open ocean areas, outside of the coastal range complexes. Habitat-forming invertebrates are likely absent where sinking exercises are planned because the activity occurs in depths greater than the range for shallow-water and many deep-water coral species (approximately 3,000 m) and away from typical locations for hydrothermal vent or cold seep communities (e.g., seamounts, Mid-Atlantic Ridge) (Cairns, 2007). It is unlikely that deep-sea hard corals could be impacted by a sinking ship hulk or fragments of a hulk due to their lack of occurrence below depths of about 3,000 m (the depth of the aragonite saturation boundary; see Section 3.4.2.1.1, Habitat Use).

Decelerators/parachutes of varying sizes are used during training and testing activities and may be deployed from aircraft or vessels. Similar to other marine debris such as derelict fishing gear, decelerators/parachutes may kill or injure sessile benthic invertebrates due to covering/shading or abrasion. Activities that expend sonobuoy and air-launched torpedo decelerators/parachutes generally occur in relatively deep water away from the shore. Because they are in the air and water column for a time span of minutes, it is improbable that a decelerator/parachute deployed over deep water could travel far enough to affect shallow-water species (e.g., shallow-water corals). Decelerators/parachutes expended over deep offshore areas may impact deep-water invertebrates (particularly sessile species) by disturbance, strikes, burial, smothering, or abrasion. For example, a decelerator/parachute could cover a sponge or deep-water coral and impair feeding.

3.4.3.4.3.1 Impacts from Military Expended Materials Under Alternative 1

Impacts from Military Expended Materials Under Alternative 1 for Training Activities

As indicated in Appendix F (Military Expended Materials and Direct Strike Impact Analysis), under Alternative 1, areas with the greatest amount of expended materials are expected to be the Northeast and Southeast U.S. Continental Shelf and the Gulf Stream Open Ocean Area—specifically within the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. In addition, military expended materials would be deposited at six inshore water locations. Offshore areas with the highest number of acres impacted by military expended materials would include the Virginia Capes and Jacksonville Range Complexes, and areas used for sinking exercises. Expended materials in inshore waters would include items such as flares (including flare o-rings and compression pad or pistons), marine markers, mine shapes, and non-explosive small-caliber munitions. Most items expended in inshore waters would occur in the James River and tributaries, Lower Chesapeake Bay, and Port Canaveral, Florida.

Military expended materials (munitions and items other than munitions) have the potential to impact invertebrates at the water surface and on the bottom throughout the Study Area. As described in detail in Section 3.4.3.4.3 (Impacts from Military Expended Materials), impacts may include injury or mortality due to direct strike or burial, disturbance, and indirect effects such as increased turbidity. The potential for direct strikes of pelagic zooplankton and squid at the surface would be minimized by their decreased occurrence in surface waters during the day when training activities typically occur.

Proportional impact analysis determined that the total bottom area affected by all military expended materials in all training areas would be about 108 acres annually (see Table F-31, Proportional Impact to Bottom Habitat from Training Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). This represents only thousandths of 1 percent of available bottom habitat in any range complex. The areas impacted by bottom type would be approximately 12 acres (hard substrate), 11 acres (intermediate substrate), 85 acres (soft substrate), and less than 2 acres (unknown substrate). The substrate types and associated invertebrate assemblages within the potentially disturbed areas are difficult to predict, as discussed in Appendix F (Military Expended Materials and Direct Strike Impact Analysis). Activities occurring at depths of less than about 3,000 m may impact deep-water corals, particularly in the Jacksonville Range Complex where ivory tree coral is apparently more abundant. However, activities conducted in relatively deep water throughout the Study Area have the potential to impact hard bottom communities, including deep-water corals, as well as invertebrates within all other habitat types. Consequences could include damage, injury, or mortality as a result of projectiles, munitions, or other items. Decelerators/parachutes, wires, and cables could also impact benthic communities if they are mobilized by water currents, although it is expected that most such materials would become buried, encrusted, or otherwise immobilized over time and would not continue to impact individual invertebrates or invertebrate assemblages. Impacts would be most pronounced if all the materials expended within the applicable depth range were deposited on areas of hard substrate supporting long-lived, sessile organisms such as deep-water corals, because it may be assumed that many of the benthic invertebrates present in the impact area footprint would be killed, injured, displaced, or disturbed by the expended materials. In addition, some previously undisturbed bottom area would be affected by activities in subsequent years. Conversely, impacts would be less if the materials were deposited on soft bottom areas containing invertebrate communities that recover relatively quickly from disturbance. Although hard substrate potentially supporting deep-water corals and other invertebrate communities is present on the continental shelf break and slope in at least some areas in water depths less than 3,000 m, a scenario of all expended materials being deposited on such substrate is unrealistic. A low percentage of deep substrate on the continental shelf is suitable for hard bottom communities, and the results of limited investigation indicate a low percentage of this available hard substrate may be inhabited by deep-water corals or other invertebrate species in some areas (Harter et al., 2009; U.S. Department of the Navy, 2010). In other areas, such as parts of the Gulf of Maine, the shelf break offshore of central Florida (Atlantic side), and the west Florida shelf, deep-water corals may cover a greater portion of available hard habitat (refer to Section 3.4.2.3.3, Corals, Hydroids, Jellyfish [Phylum Cnidaria]). However, it is expected that most of the bottom type affected would be soft substrate (Appendix F, Military Expended Materials and Direct Strike Impact Analysis). Therefore, although it is possible for a portion of expended items to impact hard substrate and associated sensitive invertebrate communities, the number of exposed individuals would not likely affect the overall viability of populations or species. While the potential for overlap between Navy activities and invertebrates is reduced for those species living in rare habitats, if overlap does occur, any potential impacts would be amplified for those invertebrate species or taxa with limited spatial extent. With the exception of some shallow-water corals, detailed distribution and habitat utilization information sufficient to support species-specific analysis is generally unavailable.

The impact of military expended materials on marine invertebrates is likely to cause injury or mortality to individuals of soft-bodied species that are smaller than the military expended materials. Zooplankton could therefore be impacted by most military expended materials. Impacts to populations would likely be inconsequential because the number of individuals affected would be small relative to known population sizes, the area exposed to the stressor is extremely small relative to the area of both suitable and occupied habitats, the activities are dispersed such that few individuals would likely be exposed to more than one event, and exposures would be localized and would cease when the military expended material becomes part of the bottom (e.g., buried or encrusted with sessile organisms). However, as discussed previously, research has shown that sedentary/sessile invertebrate communities growing on artificial substrate are often different than those found on natural substrates. Activities involving military expended materials are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Potentially impacted invertebrates include ESA-listed corals and species associated with sensitive habitats such as shallow-water, deep-water, and mesophotic reefs and live hard bottom. Most shallow-water corals in the Study Area occur within or adjacent to the Key West Range Complex, and all ESA-listed coral species occur within the Range Complex. Critical habitat for elkhorn coral and staghorn coral also occurs in the Key West Range Complex, although small areas around Naval Air Station Key West are excluded from designation (Section 3.4.2.2.1.1, Status and Management). Training activities involving military expended materials in the Key West Range Complex could therefore impact ESA-listed corals by direct strike and could expose substrate to disturbances that could degrade the quality, and potentially the quantity, of elkhorn and staghorn coral critical habitat. Important elements of critical habitat consist of hard substrates. Wires and cables could kill or injure corals due to abrasion.

Military expended materials used in the Key West Range Complex are mostly medium-caliber projectiles, decelerators/parachutes, chaff and flares, flare o-rings, endcaps, and pistons. Recovered items consist of aerial targets and drones. Chaff and flares have minimal to no potential to substantially affect corals. With the exception of mine neutralization and explosive ordnance disposal training, materials are primarily expended far from shore. Most weapons firing takes place in offshore waters away from the source of coral eggs and larvae. Decelerator/parachute interactions are unlikely because they are generally expended in water deeper than 600 ft. and would most likely not travel far enough to impact shallow-water species. Prevailing water currents flowing parallel to the shoreline (e.g., the Loop Current, Florida Current, and Gulf Stream) would tend to prevent decelerators/parachutes from drifting onto shallow-water corals located close to shore. There would be a slightly greater potential to impact ESA-listed corals located in mesophotic habitats (water depths to 90 m) that occur seaward of the coastal zone (e.g., small sonobuoy parachutes drifting onto Pulley Ridge). However, it is unlikely that large parachutes (e.g., illumination flare parachutes) would settle on mesophotic habitats supporting ESA-listed corals because the associated activity would take place more than 40 NM from shore. These areas are not included in designated critical habitat, and relatively few ESA-listed coral species may occur in mesophotic habitats due to their typical depth distribution. It is also noted that, in a ruling on potentially listing numerous coral species under the ESA, NMFS considered human-induced physical damage such as exposure to military expended material strikes to be a “negligible to low-importance” threat to coral species and was not cited as a factor when considering listing under the ESA (Endangered and Threatened Wildlife and Plants: Proposed Listing Determinations for 82 Reef-Building Coral Species; Proposed Reclassification of *Acropora palmata* and *Acropora cervicornis* from Threatened to Endangered, 77 *Federal Register* 73219–73262 [December 7, 2012]). As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities and will not place mine shapes, anchors, or mooring devices on the seafloor within a specified distance of shallow-water coral reefs. These mitigations will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including areas inhabited by shallow-water corals.

As discussed above, potential impacts to shallow-water corals would be minimized by the offshore location of many activities involving expended materials, and by mitigation that would result in avoidance of areas potentially supporting corals for many activities. Although the likelihood of impacts is correspondingly diminished, there is some potential for corals to be exposed, particularly ESA-listed coral species occurring in deeper mesophotic areas beyond the coastal zone. Pursuant to the ESA, the use of military expended materials during training activities as described under Alternative 1 may affect ESA-listed coral species and may affect designated critical habitat for elkhorn and staghorn coral. The Navy has consulted with the NMFS, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Military Expended Materials Under Alternative 1 for Testing Activities

As indicated in Appendix F (Military Expended Materials and Direct Strike Impact Analysis), under Alternative 1, areas that involve the use of expended materials include the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems and the Gulf Stream Open Ocean Area—specifically within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes, and three Testing Ranges (Naval Underwater Warfare Center, Newport, Naval Surface Warfare Center, Panama City Division, and South Florida Ocean Measurement Facility).

Military expended materials (munitions and items other than munitions) have the potential to impact invertebrates at the water surface and on the bottom throughout the Study Area. As described in detail in Section 3.4.3.4.3 (Impacts from Military Expended Materials), impacts may include injury or mortality due to direct strike or burial, disturbance, and indirect effects such as increased turbidity. The potential for direct strikes of pelagic zooplankton and squid at the surface would be minimized by their decreased occurrence in surface waters during the day. Proportional impact analysis determined that the total bottom area affected by all military expended materials in all testing areas would be about 52 acres annually (see Table F-32, Proportional Impact to Bottom Habitat from Testing Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). This represents only thousandths of 1 percent of available bottom habitat in any range complex. The area impacted by bottom type would be approximately 5 acres (hard substrate), 5 acres (intermediate substrate), 42 acres (soft substrate), and less than 1 acre (unknown substrate). The substrate types and associated invertebrate assemblages within the disturbed area is difficult to predict, as discussed in Appendix F (Military Expended Materials and Direct Strike Impact Analysis). Activities occurring at depths of less than about 3,000 m may impact deep-water corals, particularly in the Jacksonville Range Complex where ivory tree coral is apparently more abundant. However, activities conducted in relatively deep water throughout the Study Area have the potential to impact hard bottom communities, including deep-water corals, as well as invertebrates within all other habitat types. Consequences could include damage, injury, or mortality as a result of projectiles, munitions, or other items. Decelerators/parachutes, wires, and cables could also impact benthic communities if the items are moved by water currents, although it is expected that most such materials would become buried, encrusted, or otherwise immobilized over time and would not continue to impact individual invertebrates or invertebrate assemblages. Impacts would be most pronounced if all the materials expended within the applicable depth range were deposited on areas of hard substrate supporting long-lived, sessile organisms such as deep-water corals, because it may be assumed that many of the benthic invertebrates present in the impact area footprint would be killed, injured, displaced, or disturbed by the expended materials. In addition, some previously undisturbed bottom area would be affected by activities in subsequent years. Conversely, impacts would be less if the materials were deposited on soft bottom areas containing invertebrate communities that recover relatively quickly from disturbance. Although hard substrate potentially supporting deep-water corals and other invertebrate communities is present on the continental shelf break and slope in at least some areas in water depths less than 3,000 m, a scenario of all expended materials being deposited on such substrate is unrealistic. A low percentage of deep substrate on the continental shelf is suitable for hard bottom communities and, based on the results of limited investigation, a low percentage of this available hard substrate may be inhabited by deep-water corals or other invertebrate species in some areas (U.S. Department of the Navy, 2010). In other areas, such as parts of the Gulf of Maine, the shelf break offshore of central Florida, and the west Florida shelf, deep-water corals may cover a greater portion of available hard habitat (refer to Section 3.4.2.3.3, Corals, Hydroids, Jellyfish [Phylum Cnidaria]. It is expected that most of the bottom type affected would be soft substrate (Appendix F, Military Expended Materials and Direct Strike Impact Analysis). Therefore, although it is possible for a portion of expended items to impact hard substrate and associated sensitive invertebrate communities, the number of exposed individuals would not likely affect the overall viability of populations or species.

The impact of military expended materials on marine invertebrates is likely to cause injury or mortality to individuals, particularly soft-bodied organisms that are smaller than the military expended materials. Zooplankton could therefore be impacted by most military expended materials. Impacts to populations would likely be inconsequential because the number of individuals affected would be small relative to known population sizes, the area exposed to the stressor is extremely small relative to the area of both suitable and occupied habitats, the activities are dispersed such that few individuals would likely be exposed to more than one event, and exposures would be localized and would cease when the military expended material becomes part of the bottom (e.g., buried or encrusted with sessile organisms). However, as discussed previously, research has shown that sedentary/sessile invertebrate communities growing on artificial substrate are often different than those found on natural substrates. Activities involving military expended materials are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Military expended materials used for testing in the Key West Range Complex consist of various sizes of projectiles (including a small number of non-explosive missiles), explosive torpedoes and torpedo accessories, chaff cartridges, targets (air, surface, and subsurface), bathythermographs, sabots, explosive sonobuoys, sonobuoy wires, and decelerators/parachutes. Recovered items consist of non-explosive torpedoes, unmanned aerial systems, and various types of targets. Military expended materials utilized within the South Florida Ocean Measurement Facility Testing Range include projectiles, acoustic countermeasures, various targets, anchors, bathythermographs, torpedo accessories, sonobuoys, sonobuoy wires, decelerators/parachutes, and sabots. Recovered materials include non-explosive torpedoes, various targets, anchors, and mine shapes. Materials are primarily expended far from shore, although there are exceptions, including mine countermeasure testing and unmanned underwater vehicle testing. These activities may occur in the coastal zone of the Key West Range Complex or South Florida Ocean Measurement Facility Testing Range. Non-explosive sonobuoys expended during anti-submarine tracking testing include small decelerators/parachutes that could impact ESA-listed coral species and critical habitat. Most weapons firing takes place in offshore waters away from the source of coral eggs and larvae. Decelerator/parachute interactions are unlikely because, with the exception of anti-submarine tracking, they are generally expended in water deeper than 600 ft. and would most likely not travel far enough to impact shallow-water species. Prevailing water currents flowing parallel to the shoreline (e.g., the Loop Current, Florida Current, and Gulf Stream) would tend to prevent decelerators/parachutes from drifting onto shallow-water corals located close to shore. There would be a slightly greater potential to impact ESA-listed corals located in mesophotic habitats (water depths up to 90 m) that occur seaward of the coastal zone. However, these areas are not included in designated critical habitat, and relatively few ESA-listed coral species may occur in mesophotic habitats due to their typical depth distribution.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities and will not place mine shapes, anchors, or mooring devices on the seafloor within a specified distance of mapped shallow-water coral reefs. These mitigations will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including areas inhabited by shallow-water corals.

As discussed above, potential impacts to shallow-water corals would be minimized by the offshore location of many activities involving expended materials, and by mitigation that would result in avoidance of areas potentially supporting corals for many activities. Although the likelihood of impacts is correspondingly diminished, there is some potential for corals to be exposed, particularly ESA-listed coral species occurring in deeper mesophotic areas beyond the coastal zone. Pursuant to the ESA, the use of military expended materials during testing activities as described under Alternative 1 may affect ESA-listed coral species activities and may affect designated elkhorn and staghorn coral critical habitat. The Navy has consulted with the NMFS, as required by section 7(a)(2) of the ESA in that regard.

3.4.3.4.3.2 Impacts from Military Expended Materials Under Alternative 2

<u>Impacts from Military Expended Materials Under Alternative 2 for Training Activities</u>

The locations of training activities using military expended materials would be the same under Alternatives 1 and 2. The total area affected for all training activities combined would increase by less than 1 acre annually under Alternative 2 (see Table F-31, Proportional Impact to Bottom Habitat from Training Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis), and therefore the potential impacts would be similar between the two alternatives. Refer to Section 3.4.3.4.3.1 (Impacts from Military Expended Materials Under Alternative 1) for a discussion of impacts on invertebrates.

As discussed in Section 3.4.3.4.3.1 (Impacts from Military Expended Materials Under Alternative 1), the Navy will implement mitigation to avoid impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities and will not place mine shapes, anchors, or mooring devices on the seafloor within a specified distance of shallow-water coral reefs. These mitigations will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including areas inhabited by shallow-water corals.

Potential impacts to shallow-water corals would be minimized by the offshore location of many activities involving expended materials and mitigation that would result in avoidance of areas potentially supporting corals for many activities. Although the likelihood of impacts is correspondingly diminished, there is some potential for corals to be exposed, particularly ESA-listed coral species occurring in deeper mesophotic areas beyond the coastal zone. Pursuant to the ESA, the use of military expended materials during training activities as described under Alternative 2 may affect ESA-listed coral species and may affect designated elkhorn coral and staghorn coral critical habitat.

Impacts from Military Expended Materials Under Alternative 2 for Testing Activities

The locations of testing activities using military expended materials would be the same under Alternatives 1 and 2. The total area affected for all testing activities combined would increase by less than 1 acre annually under Alternative 2 (see Table F-32, Proportional Impact to Bottom Habitat from Testing Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis), and therefore the potential impacts would be similar between the two alternatives. Refer to Section 3.4.3.4.3.1 (Impacts from Military Expended Materials Under Alternative 1) for a discussion of impacts on invertebrates. As discussed in Section 3.4.3.4.3.1 (Impacts from Military Expended Materials Under Alternative 1), the Navy will implement mitigation to avoid impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities and will not place mine shapes, anchors, or mooring devices on the seafloor within a specified distance of mapped shallow-water coral reefs. These mitigations will consequently also help avoid potential impacts on invertebrates that inhabit these areas, including areas inhabited by shallow-water corals.

Potential impacts to shallow-water corals would be minimized by the offshore location of many activities involving expended materials and mitigation that would result in avoidance of areas potentially supporting corals for many activities. Although the likelihood of impacts is correspondingly diminished, there is some potential for corals to be exposed, particularly ESA-listed coral species occurring in deeper mesophotic areas beyond the coastal zone. Pursuant to the ESA, the use of military expended materials during testing activities as described under Alternative 2 may affect ESA-listed coral species and may affect designated elkhorn coral and staghorn coral critical habitat.

3.4.3.4.3.3 Impacts from Military Expended Materials Under the No Action Alternative

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

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

3.4.3.4.4 Impacts from Seafloor Devices

For a discussion of the types of activities that use seafloor devices, where they are used, and how many activities would occur under each alternative, see Appendix B (Activity Stressor Matrices). Seafloor devices include items that are placed on, dropped on, or moved along the substrate for a specific purpose, and include mine shapes, anchor blocks, anchors, bottom-placed instruments, bottom-crawling unmanned underwater vehicles, and bottom-placed targets that are recovered (not expended). Placement or deployment of seafloor devices would cause disturbance, injury, or mortality to marine invertebrates within the footprint of the device. However, the number of individuals affected likely would be small compared to overall population numbers. These items could potentially break hard substrate and associated biogenic habitats (e.g., hard coral skeletons). Objects placed on the bottom may attract invertebrates, or provide temporary attachment points for invertebrates. Some invertebrates attached to the devices would be removed from the water when the devices are recovered. A shallow depression may remain for some time in the soft bottom sediment where an anchor was dropped, potentially altering the suitability of the affected substrate for benthic invertebrates temporarily (possibly months).

Seafloor devices may also disturb marine invertebrates outside the footprint of the device, and would cause temporary (possibly hours to days) local increases in turbidity and sedimentation near the bottom, along with some changes in scouring/deposition patterns in higher current areas with soft bottom. Sedimentation can smother sessile invertebrates, while turbidity may affect respiratory organs or impair the ability of filter-feeding invertebrates to obtain food (e.g., by clogging their feeding structures or diluting the amount of food in the surrounding volume of water). However, the brief episodes of minor turbidity associated with Navy seafloor devices would be localized and the effects do not change the substrate type. Compared to overall populations, relatively few individuals would be affected.

Precision anchoring, and the associated potential impacts, is qualitatively different than other seafloor devices because the activity involves repeated disturbance of the same soft bottom areas. Precision anchoring may result in temporary and localized disturbances to water column and bottom habitats. For example, an anchor may shift due to changing currents or vessel movement and the mooring chain may drag across the bottom, causing abrasion and impacts to benthic species (Davis et al., 2016). Anchor impacts on the bottom would likely crush a small number of benthic invertebrates. Bottom disturbance would result in localized sedimentation and turbidity, which could smother invertebrates or affect respiration or feeding. Turbidity would quickly dissipate (i.e., minutes to hours) following the exercise, and many soft bottom invertebrates are burrowing organisms that would be unaffected by shallow burial. Although precision anchoring occurs in soft bottom areas, where invertebrate populations are generally resilient to disturbance, invertebrates in designated anchorage areas may be prevented from fully recovering due to frequent and long-term use, and benthic composition may be changed compared to historical conditions.

3.4.3.4.4.1 Impacts from Seafloor Devices Under Alternative 1

Impacts from Seafloor Devices Under Alternative 1 for Training Activities

As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, seafloor devices would occur in the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems, as well as the Gulf Stream Open Ocean Area—specifically within the Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes, and within the Naval Surface Warfare Center, Panama City Division Testing Range. Most activities using seafloor devices are conducted in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. In addition, seafloor devices would occur in all inshore water locations, but primarily in the Lower Chesapeake Bay, James River and tributaries, and Truman Harbor and Demolition Key.

Seafloor devices are either stationary or move very slowly along the bottom and pose little threat to highly mobile organisms such as crabs and shrimp, with the exception of individuals that might be struck as an item settles on the bottom. Sessile or less mobile benthic organisms such as sponges, sea snails, and echinoderms would be more likely to be impacted. As discussed above in Section 3.4.3.4.4 (Impacts from Seafloor Devices), impacts may include injury or mortality due to direct strike, disturbance, smothering, and impairment of respiration or filter-feeding due to increased sedimentation and turbidity. Impacts to invertebrates resulting from movement of the devices through the water column before they contact the bottom would likely consist of only temporary displacement as the object passes by.

Although intentional placement of seafloor devices on bottom structure is avoided, activities occurring at depths less than about 3,000 m may inadvertently impact deep-water corals, other invertebrates associated with hard bottom, and other marine invertebrate assemblages. However, most activities involving seafloor devices (e.g., anchors for mine shapes, light salvage targets) are typically conducted in nearshore areas far from deep sea corals. Most seafloor devices are operated in the nearshore environment on bottom habitats suitable for deployment and retrieval (e.g., soft or intermediate bottom). Activities in all the affected range complexes, and particularly the Jacksonville Range Complex (where ivory tree coral is more abundant), have the potential to impact hard bottom and deep-water corals. Consequences of strikes could include damage, injury, or mortality for each device, mooring, or anchor. Hard substrate potentially supporting deep-water corals and other invertebrate communities is present on the continental shelf break and slope. A low percentage of deep substrate on the continental shelf is suitable for hard bottom communities. Based on the results of limited investigation, a low percentage of available hard substrate may be inhabited by deep-water corals or other invertebrate species (Harter et al., 2009; U.S. Department of the Navy, 2010), although the percentage of coverage is apparently higher is some areas such as the shelf break off central Florida. The number of organisms affected is not expected to result in impacts to the viability of invertebrate populations.

During precision anchoring, impact of the anchor on the bottom would likely crush a relatively small number of benthic invertebrates. Effects associated with turbidity and sedimentation would be temporary and localized. Precision anchoring would occur from 9 to 710 times per year in the same general location, depending on the specific range complex. Therefore, although invertebrates in soft bottom areas are generally resilient to disturbance, community composition may be chronically disturbed at anchoring sites that are used repeatedly. However, the impact is likely to be inconsequential and not detectable at the population level for species occurring in the region near the anchoring locations.

In summary, the impact of seafloor devices on mostly soft bottom invertebrates is likely to cause injury or mortality to some individuals, but impacts to populations would be inconsequential because the area exposed to the stressor is extremely small relative to the area of both suitable and occupied habitats, and the activities are generally dispersed such that few individuals would likely be exposed to more than one event (although seafloor device use is concentrated in some areas such as anchorages and mine ranges). In addition, exposures would be localized and temporary, and the organisms most frequently impacted would be burrowing soft bottom invertebrates that are relatively resilient to localized sediment disturbance. Activities involving seafloor devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

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

A relatively small number of activities involving seafloor devices would be conducted in the Key West Range Complex, where all ESA-listed coral species, as well as designated elkhorn coral and staghorn coral critical habitat, occur. Seafloor devices would consist of a small number of bottom-placed instruments and metal plates. Bottom-disturbing activities have the potential to impact protected coral species and critical habitat. The metal plates are associated with activities that would be avoided in or near mapped areas of shallow-water coral reefs, per established mitigation measures. The activity using bottom-placed instruments in the Key West Range Complex does not have mitigation measures that explicitly avoid shallow-water coral reefs and may occur in the coastal zone. However, the probability of striking an ESA-listed coral species is considered negligible given the intended recovery of the instruments, ESA-listed coral species habitats represent a tiny fraction of the total area in the Key West Range Complex mostly very close to shore, and living coral represent an even smaller fraction of the total habitat area. Recovered instruments would most likely be placed on soft substrates, where ESA-listed coral species do not occur. Impacts to ESA-listed coral species would be limited to instances where seafloor devices were inadvertently used in areas of unknown hard substrate that is colonized by corals. Although unlikely, there is some potential for corals to be exposed. Pursuant to the ESA, the use of seafloor devices during training activities as described under Alternative 1 may affect ESA-listed coral species and may affect designated elkhorn and staghorn coral critical habitat. The Navy has consulted with the NMFS, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Seafloor Devices Under Alternative 1 for Testing Activities

As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, the use of seafloor devices would occur in the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems, the Gulf of Mexico Large Marine Ecosystems, and the Gulf Stream Open Ocean Area—specifically within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes; Naval Undersea Warfare Center Division, Newport Testing Range, Naval Surface Warfare Center, Panama City Division Testing Range, and the South Florida Ocean Measurement Facility Testing Range.

Seafloor devices are either stationary or move very slowly along the bottom and pose little threat to highly mobile organisms such as crabs and shrimp, with the exception of individuals that might be struck as a device settles on the bottom. Sessile or less mobile benthic organisms such as sponges, sea snails, and echinoderms would be more likely to be impacted. As discussed in Section 3.4.3.4.4 (Impacts from Seafloor Devices), impacts may include injury or mortality due to direct strike, disturbance, smothering, and impairment of respiration or filter-feeding due to increased sedimentation and turbidity. Impacts to invertebrates resulting from movement of the devices through the water column before they contact the bottom would likely consist of only temporary displacement as the object passes by.

In testing areas where bottom-crawling unmanned underwater vehicles are used, benthic organisms would be exposed to strike and disturbance in the relatively small area transited by the vehicles. Potential consequences of a strike by bottom-crawling unmanned underwater vehicles would be dependent upon the type of benthic invertebrate encountered. Within the Naval Undersea Warfare Center Division, Newport Testing Range and the Naval Surface Warfare Center, Panama City Division Testing Range where soft bottom habitats predominate, impacts would consist primarily of disturbance; burrowing invertebrates are unlikely to be injured or killed as a result of pressure exerted by bottom-crawling vehicles. The largest unmanned underwater vehicle weighs 92 lb. out of the water and has a footprint of 4.8 square feet. Assuming, worst case, that the unmanned underwater vehicle's buoyant weight is 92 lb., it exerts a pressure of only 0.133 lb. per square inch. Few benthic marine invertebrates would be injured by this pressure level, particularly over soft sediments, which would compress under the invertebrate and relieve some of the pressure being exerted by the crawler.

Although intentional placement of seafloor devices on hard substrate is avoided, activities occurring at depths less than about 3,000 m may inadvertently impact deep-water corals, other invertebrates associated with live hard bottom, and other marine invertebrate assemblages. Activities in the Northeast, Virginia Capes, and Gulf of Mexico Range Complex, and particularly the Jacksonville Range Complex, have the potential to impact live hard bottom and deep-water corals. However, most activities involving seafloor devices (e.g., anchors for mine shapes, bottom crawlers) are typically conducted in the nearshore ocean far from deep sea corals. Most seafloor devices are operated in the nearshore environment, away from shallow-water corals and on bottom habitats suitable for deployment and retrieval (e.g., soft or intermediate bottom). Consequences of a strike could include damage, injury, or mortality for each device, mooring, or anchor. Hard substrate potentially supporting deep-water corals and other invertebrate communities is present on the continental shelf break and slope. A low percentage of bottom habitat in deep portions of the continental shelf is suitable for hard bottom communities. Based on the results of limited investigations, a low percentage of available hard substrate may be inhabited by deep-water corals or other invertebrate species (U.S. Department of the Navy, 2010), although the percentage of coverage is apparently higher is some areas such as the shelf break off central Florida. Individual organisms would not likely be affected directly or indirectly to the extent that the viability of populations or species would be impacted.

The impact of seafloor devices on mostly soft bottom invertebrates is likely to cause injury or mortality to some individuals, but impacts to populations would be inconsequential because the area exposed to the stressor is extremely small relative to the area of both suitable and occupied habitats, and the activities are generally dispersed such that few individuals would likely be exposed to more than one event (although seafloor device use is concentrated in some areas such as anchorages and mine ranges). In addition, exposures would be localized and temporary, and the organisms most frequently impacted would be burrowing soft bottom invertebrates that are relatively resilient to localized sediment disturbance. Activities involving seafloor devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

All ESA-listed coral species occur in the Key West Range Complex and the South Florida Ocean Measurement Facility Testing Range and would have the potential to be exposed to seafloor devices. While critical habitat for staghorn and elkhorn coral has been designated in the Key West Range Complex and within part of the shallow (less than 30 m) nearshore portion of the South Florida Ocean Measurement Facility Testing Range, testing activities that involve the use of seafloor devices mainly occur offshore in deeper water. Furthermore, the use of seafloor devices is not likely to overlap with mapped hard substrate.

The Navy will implement mitigation to avoid potential impacts from seafloor devices on seafloor resources in mitigation areas within the South Florida Ocean Measurement Facility, as discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources). For example, the Navy will use real-time geographic information system and global positioning system (along with remote sensing verification) during deployment, installation, and recovery of anchors and mine-like objects to avoid impacts on shallow-water coral reefs and live hard bottom. This mitigation will consequently help avoid potential impacts on invertebrates that occur in these areas.

Based on the preceding discussion, impacts to ESA-listed coral species would be limited to instances where seafloor devices were inadvertently used in areas of unknown hard substrate that is colonized by corals. Although unlikely, there is some potential for corals to be exposed. Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 1 may affect ESA-listed coral species and may affect designated elkhorn and staghorn coral critical habitat. The Navy has consulted with the NMFS, as required by section 7(a)(2) of the ESA in that regard.

3.4.3.4.4.2 Impacts from Seafloor Devices Under Alternative 2

Impacts from Seafloor Devices Under Alternative 2 for Training Activities

The locations, number and type of training activities, and potential effects associated with seafloor devices would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.4.4.1 (Impacts from Seafloor Devices Under Alternative 1) for a discussion of impacts on invertebrates.

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

A relatively small number of activities involving seafloor devices would be conducted in the Key West Range Complex, where all ESA-listed coral species, as well as designated elkhorn coral and staghorn coral critical habitat, occur. Seafloor devices would consist of a small number of bottom-placed instruments and metal plates. Bottom-disturbing activities have the potential to impact protected coral species and critical habitat. The metal plates are associated with activities that would be avoided in or near mapped areas of shallow-water coral reefs, per established mitigation measures. The activity using bottom-placed instruments in the Key West Range Complex does not have mitigation measures that explicitly avoid shallow-water coral reefs and may occur in the coastal zone. However, the probability of striking an ESA-listed coral species is considered negligible given the intended recovery of the instruments, the location of such activities in harbors and away from mapped areas of shallow-water coral reefs, and the fact that ESA-listed coral species habitats represent a tiny fraction of the total area in the Key West Range Complex mostly very close to shore and living coral represent an even smaller fraction of the total habitat area. Recovered instruments would most likely be placed on soft substrates, where ESA-listed coral species do not occur. Impacts to ESA-listed coral species would be limited to instances where seafloor devices were inadvertently used in areas of unknown hard substrate that is colonized by corals. Although unlikely, there is some potential for corals to be exposed. Pursuant to the ESA, the use of seafloor devices during training activities under Alternative 2 may affect ESA-listed coral species and designated elkhorn and staghorn coral critical habitat.

Impacts from Seafloor Devices Under Alternative 2 for Testing Activities

The locations and type of testing activities using seafloor devices would be the same under Alternatives 1 and 2. There would be a very small increase in the number of testing activities using seafloor devices. However, the increase would not result in substantive changes to the potential for or the types of impacts on invertebrates. Refer to Section 3.4.3.4.4.1 (Impacts from Seafloor Devices Under Alternative 1) for a discussion of impacts on invertebrates.

The Navy will implement mitigation to avoid potential impacts from seafloor devices on seafloor resources in mitigation areas within the South Florida Ocean Measurement Facility, as discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources). For example, the Navy will use real-time geographic information and global positioning systems (along with remote-sensing verification) during deployment, installation, and recovery of anchors and mine-like objects to avoid impacts on shallow-water coral reefs and live hard bottom. This mitigation will consequently help avoid potential impacts on invertebrates that occur in these areas.

Impacts to ESA-listed coral species would be limited to instances where seafloor devices were inadvertently used in areas of unknown hard substrate that is colonized by corals. Although unlikely, there is some potential for corals to be exposed. Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 2 may affect ESA-listed coral species and may affect designated elkhorn and staghorn coral critical habitat.

3.4.3.4.4.3 Impacts from Seafloor Devices Under the No Action Alternative

Impacts from Seafloor Devices Under the No Action Alternative for Training and Testing Activities

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

3.4.3.4.5 Impacts from Pile Driving

In this section, impacts to invertebrates resulting from pile driving and vibratory pile extraction are considered in the context of injury, mortality, or displacement that may occur due to physical strikes and disturbance. Pile driving produces impulsive sound that may also affect invertebrates. Impacts associated with impulsive sound are discussed with other acoustic stressors in Section 3.4.3.1.4 (Impacts from Pile Driving).

Installation and removal of piles could crush or injure invertebrates due to direct physical impact. Direct impacts would be most likely for sessile or slow-moving species such as bivalve molluscs, worms, and echinoderms. Individuals located near the activities but not directly impacted could be disturbed and show behavioral reactions (e.g., fleeing from the area, shell closure, changes in activity). Behavioral reactions require energy expenditure and may result in additional effects such as feeding disruption or increased exposure to predators.

Bottom disturbance resulting from pile installation and removal would result in sediment displacement and turbidity. Suspended sediment particles may affect respiratory organs or impair the ability of filter-feeding invertebrates to obtain food (e.g., by clogging their feeding structures or diluting the amount of food in the surrounding volume of water).

3.4.3.4.5.1 Impacts from Pile Driving Under Alternative 1

Impacts from Pile Driving Under Alternative 1 for Training Activities

Under Alternative 1, one event involving pile driving and removal would occur annually in the nearshore and surf zone at one of the following locations: Virginia Capes Range Complex (Joint Expeditionary Base Little Creek, Virginia or Joint Expeditionary Base Fort Story, Virginia) or Navy Cherry Point Range Complex (Marine Corps Base Camp Lejeune, North Carolina) (Section 3.0.3.3.1.3, Pile Driving). Each annual event would consist of intermittent disturbance over an estimated 20 days during installation and 10 days during removal. Invertebrates could be exposed to substrate vibration and other disturbance for a total of 90 minutes per 24-hour period during installation, and could be similarly exposed for a total of 72 minutes per 24-hour period during pile removal.

Invertebrates could be crushed, injured, displaced, or react behaviorally as a result of pile installation and removal. In addition, turbidity could affect respiration and feeding in some individuals. However, this activity occurs along high energy beaches where organisms are resilient to frequent sediment disturbance. During the relatively short duration that piles are in the water (less than 2 weeks per year), limited colonization of the piles by fast-growing, sedentary invertebrates would likely occur. For example, the planktonic young of sedentary invertebrates such as mussels, hydroids, bryozoans, sea squirts, and sponges could use the piles for attachment. Adults of mobile species such as crabs could use the piles for foraging or refuge. Removal of the piles would result in mortality to limited-mobility and attached sessile species, and displacement and possibly injury to more mobile species. Compared to overall population size, only a very small number of individuals would be affected. In addition, pile driving events would occur infrequently (once per year), and impacts to the sandy substrate would be recoverable. Effects to overall invertebrate populations would not be discernable.

ESA-listed coral species and critical habitat do not occur in areas proposed for pile driving. Pursuant to the ESA, the use of pile driving during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Pile Driving Under Alternative 1 for Testing Activities

There would be no pile driving or vibratory pile extraction associated with testing activities. Therefore, pile driving is not analyzed in this subsection.

3.4.3.4.5.2 Impacts from Pile Driving Under Alternative 2

Impacts from Pile Driving Under Alternative 2 for Training Activities

The locations, number of training events, and potential effects associated with pile driving and vibratory pile extraction would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.4.5.1 (Impacts from Pile Driving Under Alternative 1) for a discussion of impacts on invertebrates.

ESA-listed coral species and critical habitat do not occur in areas proposed for pile driving. Pursuant to the ESA, the use of pile driving during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Pile Driving Under Alternative 2 for Testing Activities

There would be no pile driving or vibratory pile extraction associated with testing activities. Therefore, pile driving is not analyzed in this subsection.

3.4.3.4.5.3 Impacts from Pile Driving Under the No Action Alternative

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

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

3.4.3.5 Entanglement Stressors

This section analyzes the potential entanglement impacts of the various types of expended materials used by the Navy during training and testing activities within the Study Area. Included are potential impacts from wires and cables, decelerators/parachutes, and biodegradable polymer. Aspects of entanglement stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.4 (Conceptual Framework for Assessing Effects from Entanglement). In this section, only potential impacts of these items as entanglement stressors are discussed. Abrasion and covering/shading impacts on sessile benthic invertebrates are discussed with physical impacts in Section 3.4.3.4.3 (Impacts from Military Expended Materials).

Marine invertebrates are likely less susceptible than vertebrates to entanglement, as illustrated by the fact that fishing nets which are designed to take pelagic marine invertebrates operate by enclosing or entrapping rather than entangling (Chuenpagdee et al., 2003). However, entanglement may be possible for some species and some expended items. A survey of marine debris entanglements found that marine invertebrates accounted for 16 percent of all animal entanglements (Ocean Conservancy, 2010). The same survey cites potential entanglement in military items only in the context of waste-handling aboard ships, and not for military expended materials. A summary of the effects of litter on various marine species identified potential impacts to some invertebrate taxa, particularly mobile benthic species such as crabs and sea stars, that may become entangled in debris (e.g., nets) after attempting to move through the items (National Oceanic and Atmospheric Administration Marine Debris Program, 2014b). The potential for a marine invertebrate to become entangled in wires, cables, decelerators/parachutes, or biodegradable polymer is considered remote. The materials generally do not have the characteristics required to entangle marine species. Wires and cables are essentially rigid lines. Sonobuoy components may include plastic mesh and a float unit. Although mesh items have increased potential for entangling marine animals in general, and invertebrates can become entangled in nets (Ocean Conservancy, 2010), invertebrates are not particularly susceptible to entanglement in these items. Decelerators/parachutes have large openings between the cords separating the decelerator/parachute fabric from the release mechanism. There is no plausible scenario in which decelerator/parachute cords would tighten around and hold a mobile invertebrate. Decelerators/parachutes sink slowly through the water column, although many have weights attached to their lines to speed their sinking. Invertebrates in the water column with limited mobility (e.g., jellyfish, zooplankton) could be trapped in decelerator/parachute fabric as it sinks. The potential effects of decelerators/parachutes covering sessile invertebrate species on the bottom is discussed in Section 3.4.3.4.3 (Impacts from Military Expended Materials). Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material would break down into small pieces within a few days to weeks and break down further and dissolve into the water column within weeks to a few months.

3.4.3.5.1 Impacts from Wires and Cables

Fiber optic cables, torpedo guidance wires, sonobuoy wires, and expendable bathythermograph wires would be expended during training and testing activities. For a discussion of the types of activities that use wires and cables, see Appendix B (Activity Stressor Matrices).

A marine invertebrate could become temporarily entangled and escape unharmed, be held tightly enough that it could be injured during its struggle to escape, be preyed upon while entangled, or starve while entangled. The probability of these outcomes cannot be predicted because interactions between invertebrate species and entanglement hazards are not well known. However, it is unlikely that an invertebrate would become entangled in wires or cables. The items would be essentially linear after deployment, as they sink through the water column. Once the items reach the bottom, they could be moved into different shapes or could loop around objects due to water currents, but the items are not expected to form tight coils and the possibility of an invertebrate being ensnared is remote. Fiber-optic cables are relatively brittle and readily break if knotted, kinked, abraded against sharp objects, or looped beyond the items' bend radius of 3.4 mm. The wires and cables would eventually become buried in sediment or encrusted by marine growth, which would eliminate or further reduce the entanglement potential. The small number of most items that would be expended across the Study Area would result in an extremely low rate of potential encounter for marine invertebrates.

3.4.3.5.1.1 Impacts from Wires and Cables Under Alternative 1

Impacts from Wires and Cables Under Alternative 1 for Training Activities

Under Alternative 1, fiber optic cables, guidance wires, sonobuoy wires, and bathythermograph wires would be expended during sinking exercises, anti-submarine warfare activities, torpedo exercises, and various mine warfare and countermeasures exercises in the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems as well as the Gulf Stream and North Atlantic Gyre Open Ocean Areas – specifically within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico Range Complexes, within other AFTT areas, and within the Sink Exercise Area. The majority of expended items would be sonobuoy wires, and most of the sonobuoy wires would be expended in the Jacksonville Range Complex. The number of wires and cables expended in other areas is substantially lower.

All locations of wire and cable use potentially coincide with deep-water corals and other invertebrates associated with live hard bottom areas in water depths less than 3,000 m. Items used in the Jacksonville Range Complex in particular could potentially coincide with deep-water corals and live hard bottom habitat. The portion of suitable substrate occupied by living coral is generally low and coincidence with such low densities of linear materials is unlikely. However, in some areas such as the shelf break offshore of eastern central Florida, deep-water corals may cover a greater portion of available hard habitat (refer to Section 3.4.2.3.3, Corals, Hydroids, Jellyfish [Phylum Cnidaria]).

The impact of wires and cables on marine invertebrates is not likely to cause injury or mortality to individuals because of the linear and somewhat rigid nature of the material. Impacts to individuals and populations would be inconsequential because the area exposed to the stressor is extremely small relative to the distribution ranges of most marine invertebrates, the activities are dispersed such that few individuals would likely be exposed to more than one event, and exposures would be localized. In addition, marine invertebrates are not particularly susceptible to entanglement stressors, as most would avoid entanglement and simply be temporarily disturbed. Activities involving wires and cables are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

No activities using fiber optic cables, guidance wires, sonobuoy wires, or bathythermograph wires would occur in the Key West Range Complex. Therefore, there would therefore be no overlap of wires and cables with ESA-listed corals or critical habitat. Pursuant to the ESA, the use of wires and cables during training activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Wires and Cables Under Alternative 1 for Testing Activities

Under Alternative 1, testing activities that expend fiber optic cables, guidance wires, sonobuoy wires, and bathythermograph wires would occur in the Northeast and Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems, as well as the Gulf Stream Open Ocean Area—specifically within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes, and the Naval Surface Warfare Center, Panama City Testing Range, the Naval Undersea Warfare Center Division, Newport Testing Range, and the South Florida Ocean Measurement Facility Testing Range. The majority of expended items would be expendable bathythermograph wires and sonobuoy wires. Expendable bathythermograph wires would be expended in all the range complexes but would be concentrated in the Northeast, Virginia Capes, and Gulf of Mexico Range Complexes. Sonobuoy wires would be expended in all the range complexes, but would be concentrated in the Northeast, Virginia Capes, and Jacksonville Range Complexes.

All locations of fiber optic cable, guidance wire, and sonobuoy wire use potentially coincide with deep-water corals and other invertebrates associated with live hard bottom areas in water depths less than 3,000 m. The spatial distribution of items used in the Jacksonville Range Complex in particular could potentially coincide with deep-water corals and hard bottom habitat, although the portion of suitable substrate occupied by living coral is very low and coincidence with such low densities of linear materials is unlikely.

The impact of wires and cables on marine invertebrates is not likely to cause injury or mortality to individuals because of the linear and somewhat rigid nature of the material. Impacts to individuals and populations would be inconsequential because the area exposed to the stressor is extremely small relative to the distribution ranges of most marine invertebrates, the activities are dispersed such that few individuals would likely be exposed to more than one event, and exposures would be localized. In addition, marine invertebrates are not particularly susceptible to entanglement stressors, as most would avoid entanglement and simply be temporarily disturbed. Activities involving wires and cables are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

All ESA-listed coral species, as well as designated critical habitat for elkhorn and staghorn coral, occur within the Key West Range Complex and South Florida Ocean Measurement Facility Testing Range. A total of about 3,000 combined types of wires and cables would be expended annually in the Key West Range Complex, and a total of 42 would be expended in the South Florida Ocean Measurement Facility Testing Range. Whereas some of these materials are associated with anti-submarine warfare and torpedo testing in deeper water seaward of typical shallow-water coral occurrence, many sonobuoy wires are associated with sonobuoy lot testing in Key West. However, it is not expected that corals would be affected by entanglement in wires or cables because there is no likely scenario in which an individual coral (adult polyp, egg, or larva) would be ensnared by a wire or cable and suffer adverse effects such as restricted movement. Potential impacts to corals, including ESA-listed species, would primarily be associated with covering, shading, breakage, and abrasion. These impacts are discussed in the context of physical disturbance and strike in Section 3.4.3.4.3 (Impacts from Military Expended Materials). Elkhorn and staghorn coral critical habitat consists of exposed hard substrate or dead coral skeleton. There is no mechanism for entanglement stressors to affect these characteristics. Therefore, entanglement stressors would not degrade the quality of elkhorn or staghorn coral critical habitat. Pursuant to the ESA, the use of wires and cables during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.5.1.2 Impacts from Wires and Cables Under Alternative 2

Impacts from Wires and Cables Under Alternative 2 for Training Activities

Under Alternative 2, the locations and types of potentially entangling expended items used would be the same as Alternative 1. There would be a small increase in the number of sonobuoy wires and bathythermograph wires expended. Most of the increase would be due to the addition of sonobuoy wire expenditures in the Gulf of Mexico Range Complex. The additional items would represent an overall increase of less than 3 percent in the total number of items expended. The difference is not expected to result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.5.1.1 (Impacts from Wires and Cables Under Alternative 1) for a discussion of potential entanglement impacts resulting from wires and cables associated with training activities.

As discussed in Section 3.4.3.5.1.1 (Impacts from Wires and Cables Under Alternative 1), pursuant to the ESA, the use of wires and cables during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Wires and Cables Under Alternative 2 for Testing Activities

Under Alternative 2, the locations and types of potentially entangling expended items used would be the same as Alternative 1. There would be a small increase in the number of fiber optic cables and sonobuoy wires expended. Use of fiber optic cables would increase slightly in the Virginia Capes Range Complex and Naval Surface Warfare Center, Panama City Division Testing Range; sonobuoy wire use would increase in the Northeast, Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. The additional items would represent an overall increase of less than 2 percent of the total amount of materials expended. The difference is not expected to result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.5.1.1 (Impacts from Wires and Cables Under Alternative 1) for a discussion of potential entanglement impacts resulting from wires and cables associated with testing activities.

As discussed in Section 3.4.3.5.1.1 (Impacts from Wires and Cables Under Alternative 1), pursuant to the ESA, the use of wires and cables during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.5.1.3 Impacts from Wires and Cables Under the No Action Alternative

Impacts from Wires and Cables Under the No Action Alternative for Training and Testing Activities

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

3.4.3.5.2 Impacts from Decelerators/Parachutes

Decelerators/parachutes of varying sizes are used during training and testing activities. For a discussion of the types of activities that use decelerators/parachutes and the physical characteristics of these expended materials, see Section 3.0.3.3.5.2 (Decelerators/Parachutes). Aircraft-launched sonobuoys, lightweight torpedoes, submarine warfare training targets, aerial targets, and other devices deployed from aircraft or vessels use decelerators/parachutes that are made of nylon or a combination of cloth and nylon. Small and medium decelerators/parachutes have weights attached to the lines for rapid sinking, but large and extra-large decelerators/parachutes do not. At water impact, the decelerator/parachute assembly is expended, and it sinks away from the unit. Small and medium decelerator/parachute assemblies may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the bottom, where it becomes flattened. Large and extra-large decelerators/parachutes may remain at the surface or suspended in the water column for a longer time due to the lack of weights, but eventually also sink to the bottom and become flattened. Because they are in the air and water column for a time span of minutes, it is unlikely that a small or medium decelerator/parachute deployed in areas greater than 3 NM from the shore could travel far enough to affect shallow-water corals, including ESA-listed coral species. Larger decelerators/parachutes could move a greater distance due to their slower sinking time. Movement of the decelerator/parachute in the water or along the bottom may break more fragile invertebrates such as deep-water corals which would also reduce suitable hard substrate for encrusting invertebrates. Deep-water coral species potentially occur everywhere that decelerator/parachute use occurs. Corals (shallow-water and deep-water) are susceptible to entanglement in decelerators/parachutes, but the principal mechanisms of damage are shading, abrasion, and breakage (refer to Section 3.4.3.4.3, Impacts from Military Expended Materials, for a discussion of these impacts). On large enough spatial and temporal scales, these impacts could affect a sufficient number of individuals to reduce the extent of coral coverage. However, available studies suggest a very low percentage of suitable habitat is occupied by deep sea corals, making coincidence with entangling decelerators/parachutes very unlikely. Refer to Section 3.4.2.3.3 (Corals, Hydroids, Jellyfish [Phylum Cnidaria]) for details on the study results. In addition to corals, other sessile benthic invertebrates such as sponges, anemones, and hydrozoans could be affected by damage, burial, smothering, or abrasion.

A decelerator/parachute or attached lines sinking through the water column is unlikely to affect pelagic invertebrates. The lines would result in only temporary displacement of individuals. Most pelagic invertebrates would be too small to be ensnared, and the lines would be relatively straight as the decelerator/parachute descends, making entanglement of larger invertebrates such as jellyfish or squid highly unlikely. In addition, there are large openings between the cords. The decelerator/parachute mesh is solid, permitting only microscopic animals to pass through it. Some individuals of relatively slow-moving species (e.g., jellyfish, swimming crabs) could therefore be caught in a billowed decelerator/parachute as it sinks. However, although some are weighted, decelerators/parachutes sink relatively slowly through the water column (potential time span of minutes), and would likely impact few individuals larger than zooplankton. Any individuals trapped within the decelerator/parachute as it sinks may escape, or may remain enclosed for some time and experience potential effects similar to those described for cables and wires (e.g., injury, predation, starvation).

3.4.3.5.2.1 Impacts from Decelerators/Parachutes Under Alternative 1

Impacts from Decelerators/Parachutes Under Alternative 1 for Training Activities

Under Alternative 1, activities involving decelerator/parachute use would occur in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes, and in other AFTT areas. The vast majority of expended items would be small decelerators/parachutes; only a small number of medium, large, and extra-large decelerators/parachutes would be used. Most large decelerators/parachutes and all extra-large decelerators/parachutes would be expended in the Virginia Capes Range Complex. No large or extra-large decelerators/parachutes would be expended in the Key West Range Complex.

Decelerator/parachute lines could temporarily displace invertebrates in the water column but would be unlikely to ensnare individuals. Decelerator/parachute mesh could envelop invertebrates as the item sinks through the water column. Envelopment would primarily be associated with zooplankton, although other relatively slow-moving invertebrates such as jellyfish and swimming crabs could be caught in a billowed decelerator/parachute. Ensnared individuals may be injured or killed, or may eventually escape. Decelerators/parachutes on the bottom could cover benthic invertebrates, but some would likely be able to move away from the item. It is highly unlikely that an individual invertebrate would be ensnared by a decelerator/parachute on the bottom and suffer adverse effects. Decelerators/parachutes could break or abrade deep-water corals. These impacts are discussed in Section 3.4.3.4.3 (Impacts from Military Expended Materials) in the context of physical disturbance and strike.

The vast majority of marine invertebrates would not encounter a decelerator/parachute. The impact of decelerators/parachutes on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, the activities are dispersed such that few individuals would likely be exposed to more than one event, and exposures would be localized. The surface area of decelerators/parachutes expended across the Study Area is extremely small compared to the relatively low percentage of suitable substrate inhabited by deep-sea coral species, resulting in a low risk of coincidence. In addition, marine invertebrates are not particularly susceptible to entanglement stressors, as most would avoid entanglement and simply be temporarily disturbed. The number of individuals affected would be inconsequential compared to overall invertebrate population numbers. Activities involving decelerators/parachutes are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

A very low number of decelerators/parachutes (eight medium decelerators/parachutes per year) would be expended in the Key West Range Complex, where ESA-listed coral species and elkhorn and staghorn critical habitat occurs. In addition, ESA-listed coral species and elkhorn and staghorn coral critical habitat occurs in other AFTT areas (Caribbean Sea Large Marine Ecosystem), where small decelerators/parachutes are expended. Decelerators/parachutes are typically expended in deep, offshore waters, where shallow-water corals are unlikely to occur. Impacts to ESA-listed corals could potentially occur if decelerators/parachutes were expended in areas of unmapped shallow-water coral reefs or mesophotic coral habitat seaward of the coastal zone. Small and medium decelerators/parachutes would not be expected to drift into nearshore areas due to the sink rate of the assembly. Coral eggs or larvae could be caught in a decelerator/parachute as it strikes the water surface and sinks, although microscopic organisms may be able to pass through the mesh. Individual coral polyps that are attached to hard structure would not likely be entangled in the context of being ensnared and experiencing subsequent effects such as restricted movement. Impacts would be associated with covering, shading, and abrasion that could occur to individuals or groups of individuals if a decelerator/parachute became entangled on hard structure. These impacts are discussed in the context of physical disturbance and strike in Section 3.4.3.4.3 (Impacts from Military Expended Materials). Elkhorn and staghorn coral critical habitat consists of exposed hard substrate or dead coral skeleton. There is no mechanism for entanglement stressors to affect these characteristics. Therefore, entanglement stressors would not degrade the quality of elkhorn or staghorn coral critical habitat. Based on the discussion above, pursuant to the ESA, the use of decelerators/parachutes during training activities as described for Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Decelerators/Parachutes Under Alternative 1 for Testing Activities

Under Alternative 1, activities involving decelerators/parachute use would occur in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes, and in the Naval Underwater Warfare Center, Newport, Naval Surface Warfare Center, Panama City, and South Florida Ocean Measurement Facility Testing Ranges. The vast majority of expended items would be small decelerators/parachutes. Only a low number of large decelerators/parachutes would be used, and no extra-large parachutes would be expended.

Decelerator/parachute lines could temporarily displace invertebrates in the water column but would be unlikely to ensnare individuals. Decelerator/parachute mesh could envelop invertebrates as the item sinks through the water column. Envelopment would primarily be associated with zooplankton, although other relatively slow-moving invertebrates such as jellyfish and swimming crabs could be caught in a billowed decelerator/parachute. Ensnared individuals may be injured or killed, or may eventually escape. Decelerators/parachutes on the bottom could cover benthic invertebrates, but some would likely be able to move away from the item. It is highly unlikely that an individual invertebrate would be ensnared by a decelerator/parachute on the bottom and suffer adverse effects. Decelerators/parachutes could break or abrade deep-water corals. These impacts are discussed in Section 3.4.3.4.3 (Impacts from Military Expended Materials) in the context of physical disturbance and strike.

The vast majority of marine invertebrates would not encounter a decelerator/parachute. The impact of decelerators/parachutes on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because the area exposed to the stressor is extremely small relative to the distribution ranges of most marine invertebrates, the activities are dispersed such that few individuals would likely be exposed to more than one event, and exposures would be localized. The surface area of decelerators/parachutes expended across the Study Area is extremely small compared to the relatively low percentage of suitable substrate inhabited by deep-sea coral species, resulting in a low risk of coincidence. In addition, marine invertebrates are not particularly susceptible to entanglement stressors, as most would avoid entanglement and simply be temporarily disturbed. The number of individuals affected would be inconsequential compared to overall invertebrate population numbers. Activities involving decelerators/parachutes are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

A total of approximately 3,000 small decelerators/parachutes would be expended in the Key West Range Complex and South Florida Ocean Measurement Facility Testing Range, where ESA-listed coral species and elkhorn and staghorn critical habitat occur. Decelerators/parachutes are typically expended in deep, offshore waters, where shallow-water corals are unlikely to occur. Impacts to shallow-water corals could potentially occur if decelerators/parachutes were expended in areas of unmapped shallow-water coral reefs or mesophotic coral habitat seaward of the coastal zone. Decelerators/parachutes would not be expected to drift into nearshore areas potentially supporting corals due to the sink rate. Coral eggs or larvae could be caught in a decelerator/parachute as it strikes the water surface and sinks, although microscopic organisms may be able to pass through the mesh. Individual coral polyps that are attached to hard structure would not likely be entangled in the context of being ensnared and experiencing subsequent effects such as restricted movement. However, individuals or groups of individuals could be impacted by covering, shading, and abrasion if a decelerator/parachute became entangled on the reef structure. These impacts are discussed in the context of physical disturbance and strike in Section 3.4.3.4.3 (Impacts from Military Expended Materials). Elkhorn and staghorn coral critical habitat consists of exposed hard substrate or dead coral skeleton. There is no mechanism for entanglement stressors to affect these characteristics; impacts due to breakage of hard structures are discussed in Section 3.4.3.4.3 (Impacts from Military Expended Materials). Therefore, entanglement stressors would not degrade the quality of elkhorn or staghorn coral critical habitat. Based on the discussion above, pursuant to the ESA, the use of decelerators/parachutes during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.5.2.2 Impacts from Decelerators/Parachutes Under Alternative 2

Impacts from Decelerators/Parachutes Under Alternative 2 for Training Activities

Under Alternative 2, the locations and number of decelerators/parachutes expended would be the same as Alternative 1, with one exception. Under Alternative 2, small decelerators/parachutes would be expended in the Gulf of Mexico Range Complex. This would result in 702 additional decelerators/parachutes expended, which represents an increase of less than 2 percent compared to Alternative 1. The difference is not expected to result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.5.2.1 (Impacts from Decelerators/Parachutes Under Alternative 1) for a discussion of potential entanglement impacts resulting from decelerators/parachutes associated with training activities.

As discussed in Section 3.4.3.5.2.1 (Impacts from Decelerators/Parachutes Under Alternative 1), pursuant to the ESA, the use of decelerators/parachutes during training activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

Impacts from Decelerators/Parachutes Under Alternative 2 for Testing Activities

Under Alternative 2, the locations of activities using decelerators/parachutes would be the same as Alternative 1. Under Alternative 2, 420 more small decelerators/parachutes would be expended throughout the Northeast, Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes compared to Alternative 1. The difference represents an increase of about 2 percent and would not be expected to result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.5.2 (Impacts from Decelerators/Parachutes) for a discussion of potential entanglement impacts resulting from decelerators/parachutes associated with testing activities.

As discussed in Section 3.4.3.5.2.1 (Impacts from Decelerators/Parachutes Under Alternative 1), pursuant to the ESA, the use of decelerators/parachutes during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.5.2.3 Impacts from Decelerators/Parachutes Under the No Action Alternative

Impacts from Decelerators/Parachutes Under the No Action Alternative for Training and Training Activities

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

3.4.3.5.3 Impacts from Biodegradable Polymer

Biodegradable polymer is an expended item that is designed to temporarily interact with the propeller(s) of target craft. For a discussion of the types of activities that use biodegradable polymer material and the physical characteristics of these expended materials, see Section 3.0.3.3.5.3 (Biodegradable Polymer). The material would degrade into small pieces within a few days to weeks, after which time the entanglement potential would cease. Impacts to pelagic invertebrates would most likely be limited to temporary displacement as the biodegradable polymer material floats past an animal. Although it is unlikely that most invertebrates would become entangled in the biodegradable polymer material, entanglement is conceivable for relatively large invertebrates that occur in the water column (e.g., jellyfish and squid). Entanglement impacts to benthic species are not expected due to the relatively rapid degradation of the items.

3.4.3.5.3.1 Impacts from Biodegradable Polymer Under Alternative 1

Impacts from Biodegradable Polymer Under Alternative 1 for Training Activities

There would be no use of biodegradable polymer associated with training activities. Therefore, biodegradable polymer is not analyzed in this subsection.

Impacts from Biodegradable Polymer Under Alternative 1 for Testing Activities

Under Alternative 1, a small number of testing activities would involve the use of biodegradable polymer in the Virginia Capes, Jacksonville, Key West, and Gulf of Mexico Range Complexes, and in the Naval Undersea Warfare Center Division, Newport Testing Range. It is conceivable that relatively large pelagic invertebrates such as jellyfish would be temporarily entangled, although the probability is low due to the polymer design. The most likely effect would be temporary displacement as the material floats past an animal. Impacts to benthic species would not be expected. Activities involving biodegradable polymer would not yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Biodegradable polymer would be used in the Key West Range Complex and could therefore potentially be transported by water currents to areas occupied by ESA-listed corals or into elkhorn and staghorn coral critical habitat. However, the polymer material would be expected to remain buoyant until substantial degradation occurs and would have little potential for entanglement of sessile corals. Coral larvae in the water column would not be entangled due to their small size relative to the polymer material. Degraded polymer material would not damage or decrease the value of critical habitat.

Pursuant to the ESA, the use of biodegradable polymer during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.5.3.2 Impacts from Biodegradable Polymer Under Alternative 2

Impacts from Biodegradable Polymer Under Alternative 2 for Training Activities

There would be no use of biodegradable polymer associated with training activities. Therefore, biodegradable polymer is not analyzed in this subsection.

Impacts from Biodegradable Polymer Under Alternative 2 for Testing Activities

The locations, number of events, and potential effects associated with biodegradable polymer use would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.5.3.1 (Impacts from Biodegradable Polymer Under Alternative 1) for a discussion of the potential impacts of biodegradable polymer on invertebrates.

Biodegradable polymer would be used in the Key West Range Complex and could therefore potentially be transported by water currents to areas occupied by ESA-listed corals or into elkhorn and staghorn coral critical habitat. However, the polymer material would be expected to remain buoyant until substantial degradation occurs and would have little potential for entanglement of sessile corals. Coral larvae in the water column would not be entangled due to their small size relative to the polymer material. Degraded polymer material would not damage or decrease the value of critical habitat. Pursuant to the ESA, the use of biodegradable polymer during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species or critical habitat.

3.4.3.5.3.3 Impacts from Biodegradable Polymer Under the No Action Alternative

Impacts from Biodegradable Polymer Under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed testing activities in the AFTT Study Area. Biodegradable polymer is not a part of ongoing Navy activities in the Study Area and this entanglement stressor would not be introduced into the marine environment under the No Action Alternative. Therefore, no change in baseline conditions of the existing environment would occur.

3.4.3.6 Ingestion Stressors

This section analyzes the potential ingestion impacts of the various types of military expended materials used by the Navy during training and testing activities within the Study Area, which may be broadly categorized as munitions and materials other than munitions. Aspects of ingestion stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.5 (Conceptual Framework for Assessing Effects from Ingestion). The Navy expends the following types of materials that could become ingestion stressors during training and testing in the Study Area: non-explosive practice munitions (small- and medium-caliber), small-caliber casings, fragments from high-explosives, fragments from targets, chaff and flares, chaff and flare accessories (including end caps, compression pads or pistons, and o-rings), and small decelerators/parachutes. Very few invertebrates are large enough to ingest intact small- and medium-caliber munitions and casings; potential impact resulting from these items would be limited to a few taxa such as squid and octopus. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, sonobuoy tubes, and marine markers are too large for any marine invertebrate to consume and are eliminated from further discussion.

Expended materials could be ingested by marine invertebrates in all large marine ecosystems and open ocean areas. Ingestion could occur at the surface, in the water column, or at the bottom, depending on the size and buoyancy of the expended object and the feeding behavior of the animal. Floating material is more likely to be eaten by animals that may feed at or near the water surface (e.g., jellyfish, squid), while materials that sink to the bottom present a higher risk to both filter-feeding sessile (e.g., sponges) and bottom-feeding animals (e.g., crabs). Most military expended materials and fragments of military expended materials are too large to be ingested by marine invertebrates, and relatively large predatory or scavenging individuals are unlikely to consume an item that does not visually or chemically resemble food (Koehl et al., 2001; Polese et al., 2015). Many arthropods such as blue crab and spiny lobster are known to discriminate between palatable and unpalatable food items inside the mouth, so in a strict sense, only items that are passed into the interior digestive tract should be considered to be ingested (Aggio et al., 2012). If expended material is ingested by marine invertebrates, the primary risk is blockage in the digestive tract. Most military expended materials are relatively inert in the marine environment, and are not likely to cause injury or mortality via chemical effects (see Section 3.4.3.7, Secondary Stressors, for more information on the chemical properties of these materials). However, pollutants (e.g., heavy metals and polychlorinated biphenyls) may accumulate on the plastic components of some military expended materials. Plastic debris pieces collected at various locations in the North Pacific Ocean had polycyclic aromatic hydrocarbons and pesticides associated with them (Rios et al., 2007). Relatively large plastic pieces could be ingested by some species. However, filter- or deposit-feeding invertebrates have the greatest potential to ingest small plastic items, and any associated pollutants could harm the individual animal or subsequently be incorporated into the food chain.

The potential for marine invertebrates to encounter fragments of ingestible size increases as the military expended materials degrade into smaller fragments over months to decades. Intact munitions, fragments of munitions, and other items could degrade into metal and plastic pieces small enough to be consumed by indiscriminate feeders, such as some marine worms. Deposit-feeding, detritus-feeding, and filter-feeding invertebrates such as amphipods, polychaete worms, zooplankton, and mussels have been found to consume microscale plastic particles (microplastics) that result from the breakdown of larger plastic items (National Oceanic and Atmospheric Administration Marine Debris Program, 2014a; Wright et al., 2013a). Ingestion by these types of organisms is the most likely pathway for degraded military expended materials to enter the marine food web. Transfer of microplastic particles to higher trophic levels was demonstrated in one experiment (Setala et al., 2014). Ingestion of microplastics may result in physical effects such as internal abrasion and gut blockage, toxicity due to leaching of chemicals, and exposure to attached pollutants. Potentially harmful bacteria may also grow on microplastic particles (Kirstein et al., 2016). In addition, consumption of microplastics may result in decreased consumption of natural foods such as algae (Cole et al., 2013). Microplastic ingestion by marine worms was shown in one study to result in lower energy reserves (Wright et al., 2013a). Microplastic ingestion has been documented in numerous marine invertebrates (e.g., mussels, worms, mysid shrimp, bivalve molluscs, zooplankton, and scleractinian corals (Cole et al., 2013; Hall et al., 2015; Setala et al., 2016; Wright et al., 2013b). In an experiment involving pelagic and benthic marine invertebrates with different feeding methods, all species exposed to microplastic particles ingested some of the items (Setala et al., 2016). Deposit-feeding worms and an amphipod species ingested the fewest particles, while bivalves and free-swimming crustaceans ingested higher amounts. Ingestion of plastic particles may result in negative physical and chemical effects to invertebrates, although invertebrates are generally able to discharge these particles from the body. Overall population-level effects across a broad range of species are currently uncertain (Kaposi et al., 2014; Wright et al., 2013b).

Biodegradable polymer materials used during marine vessel stopping activities degrade relatively quickly as a result of microbial actions or enzymes. The material breaks down into small pieces within days to weeks, and degrades into particles small enough to dissolve in the water within weeks to months. Molecules formed during degradation can range from complex to simple products, depending on whether the polymers are natural or synthetic (Karlsson & Albertsson, 1998). Items of ingestible size would therefore be produced throughout the breakdown process. However, the products are considered environmentally benign and would be dispersed quickly to undetectable concentrations.

The most abundant military expended material of ingestible size is chaff. The materials in chaff are generally nontoxic in the marine environment except in quantities substantially larger than those any marine invertebrate would likely encounter as a result of Navy training and testing activities. Chaff fibers are composed of an aluminum alloy coating on glass fibers of silicon dioxide (Section 3.0.3.3.6.3, Military Expended Materials Other Than Munitions). Chaff is similar in form to fine human hair, and is somewhat analogous to the spicules of sponges or the siliceous cases of diatoms (U.S. Department of the Navy, 1999). Many invertebrates ingest sponges, including the spicules, without suffering harm (U.S. Department of the Navy, 1999). Marine invertebrates may occasionally encounter chaff fibers in the marine environment and may incidentally ingest chaff when they ingest prey or water. Literature reviews and controlled experiments suggest that chaff poses little environmental risk to marine organisms at concentrations that could reasonably occur from military training and testing (Arfsten et al., 2002; U.S. Department of the Navy, 1999). Studies were conducted to determine the effects of chaff ingestion on various estuarine invertebrates occurring near a site of frequent chaff testing in Chesapeake Bay (Systems Consultants, 1977). American oysters (various life stages), blue crabs, blue mussels (*Mytilus edulis*), and the polychaete worm *Nereis succinea* were force fed a chaff-and-food mixture daily for a few weeks at concentrations 10 to 100 times the predicted exposure level in the Bay. Although some mortality occurred in embryonic oyster larvae from 0 to 48 hours, the authors suggest confounding factors other than chaff (e.g., contaminated experimental water) as the cause. The authors reported no statistically significant mortality or effects on growth rate for any species. Because many invertebrates (e.g., crabs, shrimp) actively distinguish between food and non-food particles, the experimental design represents an unrealistic scenario with respect to the amount of chaff consumed. An investigation of sediments in portions of Chesapeake Bay exposed to aluminized chaff release for approximately 25 years found no significant increase in concentration compared to samples collected 3.7 km from the release area (Wilson et al., 2002).

As described in Section 3.4.2 (Affected Environment), many thousands of marine invertebrate species inhabit the Study Area. Most available literature regarding the effects of debris ingestion on marine invertebrates pertains to microplastics (Goldstein & Goodwin, 2013; National Oceanic and Atmospheric Administration Marine Debris Program, 2014a; Wright et al., 2013a). Discussion of potential consumption of larger items is typically focused on fishes, reptiles, mammals, and birds. Consequently, it is not feasible to speculate in detail on which invertebrates in which locations might ingest all types of military expended materials. Despite the potential impacts, it is reasonable to conclude that relatively large military expended materials would not be intentionally consumed by actively foraging invertebrates unless they are attracted by other cues (e.g., visual cues such as flashing metal bits that squid might attack). Passively-feeding invertebrates (e.g., shellfish, jellyfish) may accidently ingest small particles by filtration or incidental adhesion to sticky mucus. The potential for impacts on invertebrates from ingestion of military expended materials is also related to the locations of Navy training and testing activities relative to invertebrate population densities. Increased invertebrate densities are associated with the highest densities of microscopic plant food, which are typically located in nearshore waters in closer proximity to nutrient sources or in areas where upwelling tends to occur. Conversely, activities that generate military expended materials occur mostly seaward of nearshore water. Small deposit-feeding, detritus-feeding, and filter-feeding invertebrates would be most likely to ingest small items such as degraded plastic particles, although lobsters reportedly may also ingest microplastics (National Oceanic and Atmospheric Administration Marine Debris Program, 2014a). Though ingestion is possible in some circumstances, due to the overall size and composition of military expended materials, impacts on populations would likely not be detectable.

Important physical and biological characteristics of ESA-listed coral species are defined in Section 3.4.2.2.1.2 (Habitat and Geographic Range), and generally include any hard substrate suitable for settlement. There is no established mechanism for ingestion stressors to affect important characteristics of this critical habitat and the discussion of potential consequences to critical habitat will not be carried forward. Potential impacts of military expended material on corals and critical habitat are discussed and analyzed as a physical impact in Section 3.4.3.4.3 (Impacts from Military Expended Materials).

3.4.3.6.1 Impacts from Military Expended Materials - Munitions

Ingestion of intact military expended materials that are munitions is not likely for most types of expended items because they are too large to be ingested by most marine invertebrates. Though ingestion of intact munitions or large fragments is conceivable in some circumstances (e.g., a relatively large invertebrate such as an octopus or lobster ingesting a small-caliber projectile), such a scenario is unlikely due to the animal’s ability to discriminate between food and non-food items. Indiscriminate deposit- and detritus-feeding invertebrates such as some marine worms could potentially ingest munitions fragments that have degraded to sediment size. Metal particles in the water column may be taken up by suspension feeders (e.g., copepods, mussels) (Chiarelli & Roccheri, 2014; Griscom & Fisher, 2004), although metal concentrations in the water are typically much lower than concentrations in sediments (Bazzi, 2014; Brix et al., 2012).

3.4.3.6.1.1 Impacts from Military Expended Materials - Munitions Under Alternative 1

<u>Impacts from Military Expended Materials - Munitions Under Alternative 1 for Training Activities</u>

Under Alternative 1, military expended materials from munitions associated with training activities that could potentially be ingested include non-explosive practice munitions (small- and medium-caliber), small-caliber casings, and fragments from high-explosives. These items could be expended throughout most of the Study Area but would be concentrated in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. Small caliber casings would also be expended in some inshore waters, primarily in the James River and tributaries and Lower Chesapeake Bay. The types of activities that would produce potentially ingestible military expended materials are listed in Appendix B (Activity Stressor Matrices). The quantity of military expended materials associated with each training location is provided in Chapter 3.0 (Affected Environment and Environmental Consequences). A general discussion of the characteristics of ingestible materials is provided in Section 3.0.3.3.6 (Ingestion Stressors).

It is possible but unlikely that invertebrates would ingest intact munitions. Deposit- and detritus-feeding invertebrates could potentially ingest munitions fragments that have degraded to sediment size, and particulate metals may be taken up by suspension feeders. Impacts on individuals are unlikely, and impacts on populations would probably not be detectable.

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

ESA-listed coral species occur in the Key West Range Complex. Military expended materials used in the Key West Range Complex consist of medium-caliber, non-explosive projectiles and a small number of missiles. The only potential impact to ESA-listed corals would be associated with ingestion of metal particles that are suspended in the water column or that may have been consumed by zooplankton on which the corals feed. With the exception of mine neutralization and countermeasures training, materials are primarily expended far from shore. Most weapons firing takes place in offshore waters, minimizing the potential for shallow-water corals to ingest metal munitions particles. There would be a slightly greater potential to impact ESA-listed corals located in mesophotic habitats (water depths to 90 m) that occur seaward of the coastal zone. The potential for corals to ingest degraded metal particles is considered remote. Pursuant to the ESA, the use of military expended materials that are munitions during training activities as described under Alternative 1 would have no effect on ESA-listed coral species.

Impacts from Military Expended Materials - Munitions Under Alternative 1 for Testing Activities

Under Alternative 1, military expended materials from munitions associated with testing activities that could potentially be ingested include non-explosive practice munitions (small- and medium-caliber) and fragments from high-explosives. These items could be expended throughout most of the Study Area but would be concentrated in the Virginia Capes and Jacksonville Range Complexes. The types of activities that would produce potentially ingestible military expended materials are listed in Appendix B (Activity Stressor Matrices). The quantity of military expended materials associated with each testing location is provided in Chapter 3.0 (Affected Environment and Environmental Consequences). A general discussion of the characteristic of ingestible materials in provided in Section 3.0.3.3.6 (Ingestion Stressors).

It is possible but unlikely that invertebrates would ingest intact munitions. Deposit- and detritus-feeding invertebrates could potentially ingest munitions fragments that have degraded to sediment size, and particulate metals may be taken up by suspension feeders. Impacts on individuals are unlikely, and impacts on populations would probably not be detectable.

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

ESA-listed coral species occur in the Key West Range Complex and South Florida Ocean Measurement Facility Testing Range. Military expended materials used in the Key West Range Complex would consist of small- and medium-caliber, non-explosive projectiles, in addition to high-explosive items (torpedoes, explosive sonobuoys, large-caliber projectiles). A very small number of explosive projectiles would be used in the South Florida Ocean Measurement Facility Testing Range. As discussed for training activities, the only potential ingestion impact to ESA-listed corals would be associated with ingestion of metal particles that are suspended in the water column or that may have been consumed by zooplankton on which the corals feed. Materials are primarily expended far from shore. Most weapons firing takes place in offshore waters away from shallow-water corals. The potential for corals to ingest degraded metal particles is considered remote. Pursuant to the ESA, the use of military expended materials that are munitions during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species.

3.4.3.6.1.2 Impacts from Military Expended Materials - Munitions Under Alternative 2

Impacts from Military Expended Materials - Munitions Under Alternative 2 for Training Activities

The types and locations of expended military munitions used would be the same under Alternatives 1 and 2. Refer to Section 3.4.3.6.1.1 (Impacts from Military Expended Materials - Munitions Under Alternative 1) for a discussion of potential ingestion impacts resulting from expended military munitions associated with training activities.

As discussed in Section 3.4.3.6.1.1 (Impacts from Military Expended Materials - Munitions Under Alternative 1), pursuant to the ESA, the use of military expended materials that are munitions during training activities as described under Alternative 2 would have no effect on ESA-listed coral species.

Impacts from Military Expended Materials - Munitions Under Alternative 2 for Testing Activities

The locations and types of expended military munitions would be the same under Alternatives 1 and 2. There would be a very small increase in the number of fragments resulting from high explosives under Alternative 2 associated with five Airborne Mine Neutralization System neutralizers and mines expended in both the Virginia Capes Range Complex and the Naval Surface Warfare Center, Panama City Division Testing Range. However, this increase would not be expected to result in substantive changes to the potential for or types of impacts on invertebrates. Refer to Section 3.4.3.6.1.1 (Impacts from Military Expended Materials - Munitions Under Alternative 1) for a discussion of potential ingestion impacts resulting from expended military munitions associated with testing activities.

As discussed in Section 3.4.3.6.1.1 (Impacts from Military Expended Materials - Munitions Under Alternative 1), pursuant to the ESA, the use of military expended materials that are munitions during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species.

3.4.3.6.1.3 Impacts from Military Expended Materials - Munitions Under the No Action Alternative

Impacts from Military Expended Materials - Munitions Under the No Action Alternative for Training and Testing Activities

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

3.4.3.6.2 Impacts from Military Expended Materials Other Than Munitions

Military expended materials other than munitions include a large number of items such as aerial countermeasures, targets (surface and aerial), mine shapes, ship hulk, small decelerators/parachutes, acoustic countermeasures, sonobuoys, and other various materials such as torpedo accessories, concrete slugs, markers, bathythermographs, and endcaps and pistons. Some expended materials are recovered, including torpedoes, unmanned aerial systems, some targets, mine shapes, metal plates, and bottom-placed instruments. Most expendable items, such as targets and target fragments, would sink to the bottom, while materials such as Styrofoam or degraded plastic particles could persist at the surface or in the water column for some time. Ingestion is not likely for most military expended materials because they are too large to be consumed by most marine invertebrates. Though ingestion of intact items on the bottom is conceivable in some circumstances (e.g., a relatively large invertebrate such as an octopus or lobster ingesting a small target fragment), such a scenario is unlikely due to the animal's ability to discriminate between food and non-food items. Similarly, it is unlikely that an invertebrate at the surface or in the water column would ingest a relatively large expended item as it floats or sinks through the water column.

Degradation of plastic materials could result in microplastic particles being released into the marine environment over time. Eventually, deposit-feeding, detritus-feeding, and filter-feeding invertebrates could ingest these particles, and there is potential for some of the particles to be transferred up trophic levels. Ingestion of plastic particles may result in negative physical and chemical effects to invertebrates. Invertebrates outside the Study Area could encounter microplastic particles if plastic items drift with ocean currents. Currently, overall population-level effects across a broad range of invertebrate species from exposures to microplastic particles are uncertain (Kaposi et al., 2014). Navy training and testing activities would result in a small amount of plastic particles introduced to the marine environment compared to other sources, as many military expended materials are not composed of plastic. The vast majority of marine debris by volume and ingestion potential consists of or is derived from non-military items (Kershaw et al., 2011).

Marine invertebrates may occasionally encounter chaff fibers and incidentally ingest chaff when they ingest prey or water. Literature reviews and controlled experiments suggest that chaff poses little environmental risk to marine organisms at concentrations that could reasonably occur from military training and testing (Arfsten et al., 2002; U.S. Department of the Navy, 1999).

3.4.3.6.2.1 Impacts from Military Expended Materials Other Than Munitions Under Alternative 1

Impacts from Military Expended Materials Other Than Munitions Under Alternative 1 for Training Activities

Under Alternative 1, a variety of potentially ingestible military expended materials would be released to the marine environment by Navy training activities, including target fragments, chaff, canisters, and flare casings. These items could be expended throughout the Study Area, including all range complexes, other AFTT areas, and inshore waters. A comparatively low number of items would be expended in most inshore waters, although a relatively large quantity of flares and related accessories (o-rings, compression pads or pistons, and endcaps) would occur in the James River and tributaries. The types of activities that would produce potentially ingestible military expended materials are listed in Appendix B (Activity Stressor Matrices). The quantity of military expended materials associated with each training location is provided in Chapter 3.0 (Affected Environment and Environmental Consequences). A general discussion of the characteristics of ingestible materials is provided in Section 3.0.3.3.6 (Ingestion Stressors).

Most invertebrates would not be able to ingest most intact expended items. Ingestion would be limited to small items, such as chaff and fragments of larger items such as targets. Deposit- and detritus-feeding invertebrates could potentially ingest small items that have degraded to sediment size, and particulate metals may be taken up by suspension feeders. In addition, small plastic pieces may be consumed by a wide variety of invertebrates with diverse feeding methods (detritivores, planktivores, deposit-feeders, filter-feeders, and suspension-feeders) in the water column or on the bottom. Adverse effects due to metal pieces on the bottom or in the water column are unlikely. Microplastic particles could affect individuals. Although the potential effects on invertebrate populations due to microplastic ingestion are currently uncertain, Navy activities would result in a small amount of plastic particles introduced to the marine environment compared to other sources. Overall, impacts on invertebrate populations due to military expended materials other than munitions would probably not be detectable.

ESA-listed coral species occur in the Key West Range Complex. Military expended materials used in the Key West Range Complex consist of chaff, flares, chaff and flare accessories, targets, and marine markers. Whereas sinking materials would become unavailable to corals, floating materials (e.g., flare compression pads) would degrade over time and release suspended particles in the water column. Materials are primarily expended far from shore where shallow-water corals do not occur, and it is unlikely that coral polyps or larvae would be impacted by ingestion of small fragments of expended items in the water column. There would be a slightly greater potential to impact ESA-listed corals located in mesophotic habitats (water depths to 90 m) seaward of the coastal zone. There is potential for corals to ingest very small particles of degraded plastic items suspended in the water column. However, no information is currently available that indicates adverse effects to coral health resulting from plastic ingestion. The vast majority of plastic waste in the ocean originates from non-military sources. Pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under Alternative 1 would have no effect on ESA-listed coral species.

Impacts from Military Expended Materials Other Than Munitions Under Alternative 1 for Testing Activities

Under Alternative 1, a variety of potentially ingestible military expended materials would be released to the marine environment by Navy testing activities, including target fragments, chaff, concrete slugs, sabots, and various other items. These items could be expended throughout most of the Study Area. However, expended materials other than munitions would not occur in inshore waters during testing activities. The types of activities that would produce potentially ingestible military expended materials are listed in Appendix B (Activity Stressor Matrices). The quantity of military expended materials associated with each testing location is provided in Chapter 3.0 (Affected Environment and Environmental Consequences). A general discussion of the characteristics of ingestible materials is provided in Section 3.0.3.3.6 (Ingestion Stressors).

Most invertebrates would not be able to ingest most intact expended items. Ingestion would be limited to small items, such as chaff and fragments of larger items. Deposit- and detritus-feeding invertebrates could potentially ingest small items that have degraded to sediment size, and particulate metals may be taken up by suspension feeders. Small plastic pieces may be consumed by invertebrates with a wide diversity of feeding methods in the water column or on the bottom. In addition, products resulting from the breakdown of biodegradable polymer would be introduced to the water column.

The types of invertebrates that could ingest these particles would vary as the material degrades into smaller particles with increasing amount of time in the water. Adverse effects due to metal pieces on the bottom or in the water column are unlikely. Microplastic particles could affect individuals. Although the potential effects on invertebrate populations due to microplastic ingestion are currently uncertain, Navy activities would result in a small amount of plastic particles introduced to the marine environment compared to other sources. Overall, impacts on invertebrate populations due to military expended materials other than munitions would probably not be detectable.

ESA-listed coral species occur in the Key West Range Complex and South Florida Ocean Measurement Facility Testing Range. Chaff, targets, mine shapes, torpedo accessories, sabots, and other items would be expended in these areas. Whereas sinking materials would become unavailable to corals, floating materials would degrade over time and release suspended particles in the water column. Materials are primarily expended far from shore where shallow-water corals do not occur, and it is unlikely that coral polyps or larvae would be impacted by ingestion of small fragments of expended items in the water column. There would be a slightly greater potential to impact ESA-listed corals in mesophotic habitats (water depths to 90 m) seaward of the coastal zone. There is potential for corals to ingest very small particles of degraded plastic items suspended in the water column. However, no information is currently available that indicates adverse effects to coral health resulting from plastic ingestion. The vast majority of plastic waste in the ocean originates from non-military sources. Pursuant to the ESA, the use of military expended materials other than munitions during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species.

3.4.3.6.2.2 Impacts from Military Expended Materials Other Than Munitions Under Alternative 2

Impacts from Military Expended Materials Other Than Munitions Under Alternative 2 for Training Activities

Under Alternative 2, the locations and types of military expended materials used would be the same as those of Alternative 1. Under Alternative 2, there would be an increase in the number of some items expended, such as targets, sonobuoys, bathythermograph equipment, and small decelerators/ parachutes. This relatively small increase in the total number of items expended would not be expected to result in substantive changes to the type or degree of impacts to invertebrates. Refer to Section 3.4.3.6.2.1 (Impacts from Military Expended Materials Other Than Munitions Under Alternative 1) for a discussion of potential ingestion impacts resulting from military expended materials other than munitions associated with training activities.

As discussed in Section 3.4.3.6.2.1 (Impacts from Military Expended Materials Other Than Munitions Under Alternative 1), pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under Alternative 2 would have no effect on ESA-listed coral species.

Impacts from Military Expended Materials Other Than Munitions Under Alternative 2 for Testing Activities

Under Alternative 2, the locations and types of military expended materials used would be the same as those of Alternative 1. Under Alternative 2, there would be a slight increase in the number of some items expended, such as subsurface targets, sonobuoys, mines, and small decelerators/parachutes. This small increase in the total number of items expended would not be expected to result in substantive changes to the type or degree of impacts to invertebrates. Refer to Section 3.4.3.6.2.1 (Impacts from

Military Expended Materials Other Than Munitions Under Alternative 1) for a discussion of potential ingestion impacts resulting from military expended materials other than munitions associated with testing activities.

As discussed in Section 3.4.3.6.1.1 (Impacts from Military Expended Materials Other Than Munitions Under Alternative 1), pursuant to the ESA, the use of military expended materials other than munitions during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species.

3.4.3.6.2.3 Impacts from Military Expended Materials Other Than Munitions Under the No Action Alternative

Impacts from Military Expended Materials Other Than Munitions Under the No Action Alternative for Training and Testing Activities

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

3.4.3.7 Secondary Stressors

This section analyzes potential impacts on marine invertebrates exposed to stressors indirectly through impacts on their habitat (sediment or water quality) or prey. The assessment of potential water and sediment quality stressors refers to previous sections (Section 3.2, Sediments and Water Quality), and addresses specific activities in local environments that may affect invertebrate habitats. The terms “indirect” and “secondary” do not imply reduced severity of environmental consequences, but instead describe how the impact may occur in an organism or its ecosystem. Stressors from Navy training and testing activities that could pose indirect impacts to marine invertebrates via habitat or prey include: (1) explosives and explosive byproducts, (2) chemicals other than explosives, and (3) metals.

Secondary or indirect stressors may impact benthic and pelagic invertebrates, gametes, eggs, and larvae by changes to sediment and water quality. Physical and biological features of ESA-listed elkhorn and staghorn coral critical habitat are defined in Section 3.4.2.2.1.2 (Habitat and Geographic Range). These characteristics can be summarized as any hard substrate of suitable quality and availability to support settlement, recruitment, and attachment at depths from mean low water to 30 m. Physical or biological features were not formally defined for these species. Exemptions from critical habitat designations include a small zone around Naval Air Station Key West and a small area within the South Florida Ocean Measurement Facility Testing Range (Section 3.4.2.2.1.1, Status and Management). However, exemption does not preclude analysis of ESA-listed coral species. Impacts to hard substrate would not result from the introduction of metal, plastic, or chemical substances into the water column. Potential impacts are associated with physical effects such as breakage or covering of hard surfaces.

Explosives and Explosives Byproducts

Secondary impacts to invertebrates resulting from explosions at the surface, in the water column, or on the bottom would be associated with changes to habitat structure and effects to prey species. Most explosions on the bottom would occur in soft bottom habitat and would displace some amount of sediment, potentially resulting in cratering. However, water movement would redistribute the affected sediment over time. A small amount of sediment would be suspended in the water column temporarily, but would resettle to the bottom. There would be no overall reduction in the surface area or volume of sediment available to benthic species that occur on the bottom or within the substrate. Activities that inadvertently result in explosions on or near hard bottom habitat or reefs could break hard structures and reduce the amount of colonizing surface available to encrusting organisms (e.g., corals, sponges).

Explosions in the water column or on the bottom could impact invertebrate prey species. Some species of most invertebrate taxa prey upon other invertebrate species, with prey items ranging in size from zooplankton to relatively large shrimps and crabs. Therefore, in a strict sense, mortality to invertebrate species resulting from an explosion may represent a reduction in prey to other invertebrate species. A few invertebrates such as squid and some jellyfish prey upon fish, although jellyfish capture fish passively rather than through active pursuit. Therefore, fish mortality resulting from an explosion would reduce the number of potential prey items for invertebrates that consume fish. In addition to mortality, fish located near a detonation would likely be startled and leave the area, temporarily reducing prey availability until the affected area is repopulated.

Some invertebrates (e.g., worms, crustaceans, sea stars) are scavengers that would feed on any vertebrate or invertebrate animal that is killed or significantly impaired by an explosion. Therefore, scavenging invertebrates that are not killed or injured themselves could benefit from physical impacts to other animals resulting from explosions in the water column or on the bottom.

High-order explosions consume most of the explosive material, leaving only small or residual amounts of explosives and combustion products. Most of the combustion products of trinitrotoluene (i.e., TNT), such as carbon dioxide and nitrogen, are common seawater constituents, although other products such as carbon monoxide are also produced (Becker, 1995). Other explosive compounds may produce different combustion products. All combustion products are rapidly diluted by ocean currents and circulation (see Section 3.2.3.1, Explosives and Explosives Byproducts). Therefore, explosives byproducts from high-order detonations would not degrade sediment or water quality or result in indirect stressors to marine invertebrates. Low-order detonations and unexploded munitions present an elevated potential for effects on marine invertebrates. Deposition of undetonated explosive materials into the marine environment can be reasonably estimated by the known failure and low-order detonation rates of high-explosives (Section 3.2.3.1, Explosives and Explosives Byproducts). Explosive materials not completely consumed during a detonation from munitions disposal and mine clearing training are collected after the activities are completed; therefore, potential impacts are likely inconsequential and not detectable for these activities.

Exposure to relatively high concentrations of various explosive materials in sediments and in the water may result in lethal and sub-lethal effects to invertebrates. The type and magnitude of effects appear to be different among various invertebrate species and are also influenced by the type of explosive material and physical characteristics of the affected water and sediment. For example, lethal toxicity has been reported in some invertebrate species (e.g., the amphipod *Eohaustorius estuarius*) exposed to trinitrotoluene (i.e., TNT), while mortality has not been found in other species (e.g., the polychaete worm *Neanthes arenaceodentata*), even when exposed to very high concentrations (Rosen & Lotufo, 2005). Exposure to water-borne explosive materials has been found to affect reproduction or larval development in bivalve, sea urchin, and polychaete worm species (Lotufo et al., 2013). Invertebrates on the bottom may be exposed to explosive materials by ingesting contaminated sediment particles, in addition to being exposed to materials in the overlying water column or in voids in the sediment (for burrowing invertebrates). However, toxicity and other sub-lethal effects have often been associated with exposure to higher concentrations of explosive materials than the concentrations expected to occur in marine or estuarine waters of the Study Area due to training and testing activities.

Indirect impacts of explosives and unexploded munitions on marine invertebrates via sediment are possible near the munitions. Rosen and Lotufo (2010) exposed mussels and deposit-feeding amphipods and polychaete worms to levels of trinitrotoluene (i.e., TNT) and royal demolition explosive potentially associated with a breached munition or low-order detonation. The authors found concentrations in the sediment above toxicity levels within about 1 in. of the materials, although no statistical increase in mortality was observed for any species. Concentrations causing toxicity were not found in the water column. Explosive material in the marine environment is readily degraded via several biotic and abiotic pathways, as discussed in Section 3.2.3.1 (Explosives and Explosives Byproducts). The results of studies of explosive material deposition at munitions disposal sites and active military water ranges suggest that explosives and explosives residues pose little risk to fauna living in direct contact with munitions, and that sediment is not a significant sink for these materials (Kelley et al., 2016; Koide et al., 2016; Smith & Marx, 2016). Munitions constituents and degradation products would likely be detectable only within a few feet of a degrading munition, and the spatial range of toxic sediment conditions could be less (inches). It has been suggested that the risk of toxicity to invertebrates in realistic exposure scenarios is negligible (Lotufo et al., 2013). Indirect impacts of explosives and unexploded munitions on marine invertebrates via water are likely to be inconsequential. Most explosives and explosive degradation products have relatively low solubility in seawater. This means that dissolution occurs extremely slowly, and harmful concentrations of explosives and degradation products are not likely to occur in the water column. Also, the low concentration of materials delivered slowly into the water column is readily diluted by ocean currents and would be unlikely to concentrate in toxic levels. Filter feeders such as sponges or some marine worms would be exposed to chemical byproducts only in the immediate vicinity of degrading explosives (inches or less) due to the low solubility and dilution by water currents. While marine invertebrates may be adversely impacted by the indirect effects of degrading explosives via water, this is unlikely in realistic scenarios.

Impacts on marine invertebrates, including zooplankton, eggs, and larvae, are likely only within a very small radius of the munition (potentially inches). These impacts may continue as the munition degrades over decades (Section 3.2.3.1, Explosives and Explosives Byproducts). Because most munitions are deployed as projectiles, multiple unexploded or low-order detonations would not likely accumulate on spatial scales as small as feet to inches; therefore, potential impacts are likely to remain local and widely separated. Explosives, explosives byproducts, and unexploded munitions would therefore generally not be present in these habitats.

Chemicals Other Than Explosives

Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment, primarily propellants and combustion products, other fuels, polychlorinated biphenyls in target vessels, other chemicals associated with munitions, and simulants (Section 3.2.3.2, Chemicals Other Than Explosives). Ammonium perchlorate (a rocket and missile propellant) is the most common chemical used. Perchlorate is known to occur naturally in nitrate salts, such as from Chile, and it may be formed by atmospheric processes such as lightning and reactions between ozone and sodium chloride in the air (associated with evaporated seawater) (Dasgupta et al., 2005; Sijimol & Mohan, 2014; U.S. Environmental Protection Agency, 2014). Perchlorate may impact metabolic processes in plants and animals. Effects have been found in earthworms and aquatic (freshwater) insects (Smith, 2002; Srinivasan & Viraraghavan, 2009), although effects specific to marine invertebrates are unknown. Other chemicals with potential for adverse effects to invertebrates include some propellant combustion products such as hydrogen cyanide and ammonia.

Potential impacts to sediments and seawater resulting from use of chemicals are discussed in Section 3.2.3.2 (Chemicals Other Than Explosives). Rockets and missiles are highly efficient at consuming propellants (for example, over 99.9 percent of perchlorate is typically consumed), and therefore very little residual material would enter the water column. Additionally, perchlorate does not readily absorb into sediments, potentially reducing the risk to deposit- and detritus-feeding invertebrates. Torpedoes are expended in the water, and therefore torpedo propellant (e.g., Otto Fuel II) combustion products would enter the marine environment. Overall, analysis concludes that impacts to sediments and water quality would be minimal for several reasons. The size of the area affected is large, and chemicals would therefore not be concentrated. Most propellant combustion byproducts are benign, and those of concern (e.g., hydrogen cyanide) would be quickly diluted. Most propellants are consumed during normal operations, and the failure rate of munitions using propellants and other combustible materials is low. Most byproducts of Otto Fuel II combustion occur naturally in seawater and most torpedoes are recovered after use, limiting the potential for unconsumed fuel to enter the water. In addition, most constituents are readily degraded by biotic and abiotic processes. Concentrations of chemicals in sediment and water are not likely to cause injury or mortality to marine invertebrates, gametes, eggs, or larvae.

Target vessels are only used during sinking exercises, which occur infrequently. Polychlorinated biphenyls may be present in certain solid materials (e.g., insulation, wires, felts, and rubber gaskets) on target vessels. The vessels are selected from a list of Navy-approved vessels that have been cleaned in accordance with USEPA guidelines. Sinking exercises must be conducted at least 50 NM offshore and in water at least 6,000 ft. deep. USEPA estimates that as much as 100 lb. of polychlorinated biphenyls remain onboard sunken target vessels. USEPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 United States Code 1341, et seq.). Under a 2014 agreement with USEPA, the Navy will not likely use aircraft carriers or submarines as the targets for a sinking exercise. As discussed in Section 3.2.3.2 (Chemicals Other Than Explosives), based on these considerations, polychlorinated biphenyls are not evaluated further as a secondary stressor to invertebrate habitats.

Metals

Certain metals and metal-containing compounds (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) are harmful to marine invertebrates at various concentrations above background levels (Chan et al., 2012; Negri et al., 2002; Wang & Rainbow, 2008). For example, physiological effects in crabs, limpets, and mussels due to copper exposure were reported (Brown et al., 2004), although the effects were found at concentrations substantially higher than those likely to be encountered due to Navy expended materials. Metals are introduced into seawater and sediments as a result of training and testing activities involving vessel hulks, targets, munitions, and other military expended materials (see Section 3.2.3.3, Metals). Some effects due to metals result from the concentrating effects of bioaccumulation, which is not discussed in this section. Bioaccumulation issues are discussed in the *Ecosystem Technical Report for the Atlantic Fleet Training and Testing (AFTT) Environmental Impact Statement* (U.S. Department of the Navy, 2012). Secondary effects may occur when marine invertebrates are exposed by contact with the metal, contact with trace amounts in the sediment or water (e.g., from leached metals), and ingestion of contaminated sediments (Brix et al., 2012)

Because metals tend to precipitate out of seawater and often concentrate in sediments, potential adverse indirect impacts are much more likely via sediment than water (Zhao et al., 2012). However, studies have found the concentrations of metals in the sediments within military ranges (e.g., Navy training areas such as Vieques, Puerto Rico) or munitions disposal sites, where deposition of metals is very high, to rarely be above biological effects levels (Section 3.2.3.3, Metals). For example, researchers sampled areas associated with Vieques in which live ammunition and weapons were used and found generally low concentrations of metals in the sediment (Pait et al., 2010). Comparison with guidelines suggested by the National Oceanic and Atmospheric Administration's National Status and Trends Program showed that average metal concentrations were below threshold effects levels for all constituents except copper, and were below probable effects levels for all constituents. The concentration of munitions at Vieques is substantially greater than would occur in the AFTT Study Area. Evidence from a number of studies at military ranges and disposal sites indicates metal contamination is very localized (Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016). Impacts to invertebrates, eggs, or larvae would likely be limited to exposure in the sediment within a few inches of the object. Refer to Section 3.2.3.3 (Metals) for more detailed study results of metal contamination in sediments at military ranges.

Concentrations of metals in sea water affected by Navy training and testing activities are unlikely to be high enough to cause injury or mortality to marine invertebrates. Benthic invertebrates occurring very near (within a few inches) Navy-derived materials on the seafloor could be impacted by associated metal concentrations, but this is expected to affect relatively few individuals.

3.4.3.7.1 Impacts on Habitat

As discussed in Section 3.4.3.7 (Secondary Stressors), impacts on invertebrate habitat resulting from explosives, explosives byproducts, unexploded munitions, metals, and chemicals would be minor overall, and the possibility of population-level impacts on marine invertebrates is remote. Explosions would temporarily disturb soft bottom sediments and could potentially damage hard structures, but the effects would likely be undetectable at the population or subpopulation level. Individuals could be killed, injured, or experience physiological effects due to exposure to metals and chemical materials (including explosives materials) in the water column or on the bottom, but these effects would be localized. The number of individuals affected would be small compared to overall population numbers.

Deposition of metal materials would provide new hard substrate that could be colonized by encrusting invertebrates (e.g., sponges, barnacles, hydrozoans, corals). The increased area of artificial hard habitat could therefore provide a benefit to some invertebrate species although, similar to the preceding discussion, any positive impacts would likely be undetectable at the population level. In addition, invertebrate communities on artificial substrate may be different than those found in adjacent natural substrate.

The potential for explosions occurring near the surface to damage seafloor resources such as ESA-listed coral habitat is considered negligible. The largest explosives are used more than 12 NM from shore where water depth is typically greater than 90 m, and explosive effects would not extend to the bottom at locations seaward of the coastal zone due to vertical compression of explosive impacts around the detonation point. Bottom explosions would not occur on known live hard bottom areas. Therefore, impacts to habitat potentially supporting ESA-listed corals would be limited to activities that are inadvertently conducted on or near unknown habitat areas. There is a relatively low abundance of suitable hard substrate in the zone between 3 and 12 NM from shore (U.S. Department of the Navy, 2018), and the results of underwater surveys at one mesopohotic reef indicate a very low abundance of hard coral species on suitable habitat in the mesopohtic zone (Reed et al., 2015). However, any impacts to hard structure could reduce the amount of adequate substrate available to ESA-listed corals. Hard substrate is considered an essential physical feature of elkhorn coral and staghorn coral critical habitat. Due to the possibility of inadvertent impacts to hard structure, explosions may affect ESA-listed coral species and critical habitat. The Navy has consulted with the NMFS, as required by section 7(a)(2) of the ESA in that regard.

3.4.3.7.2 Impacts on Prey Availability

As discussed in Section 3.4.3.7 (Secondary Stressors), impacts on invertebrate prey availability resulting from explosives, explosives byproducts, unexploded munitions, metals, and chemicals would likely be negligible overall and population-level impacts on marine invertebrates are not expected. Because individuals of many invertebrate taxa prey on other invertebrates, mortality resulting from explosions or exposure to metals or chemical materials would reduce the number of invertebrate prey items available. A few species prey upon fish, and explosions and exposure to metals and chemical materials could result in a minor reduction in the number of fish available. However, as discussed in Section 3.6.3.7 (Secondary Stressors), explosive materials, metals, and chemicals would have a negligible effect on fishes. Therefore, secondary effects to invertebrates due to reduced fish prey availability are unlikely. Any vertebrate or invertebrate animal killed or significantly impaired by Navy activities could potentially represent an increase in food availability for scavenging invertebrates. None of the effects described above would likely be detectable at the population or subpopulation level.

Pursuant to the ESA, potential effects to prey availability would have no effect on ESA-listed coral species.

3.4.4 Summary of Potential Impacts on Invertebrates

3.4.4.1 Combined Impacts of All Stressors Under Alternative 1

As described in Section 3.0.3.5 (Resource-Specific Impacts Analysis for Multiple Stressors), this section evaluates the potential for combined impacts of all stressors from the Proposed Action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in the sections above. Stressors associated with Navy training and testing activities do not typically occur in isolation but rather occur in some combination. For example, mine neutralization activities include elements of acoustic, physical disturbance and strike, entanglement, ingestion, and secondary stressors that are all coincident in space and time. An analysis of the combined impacts of all stressors considers the potential consequences of additive stressors and synergistic stressors, as described below. This analysis makes the assumption that the majority of exposures to stressors are non-lethal, and instead focuses on consequences potentially impacting the organism's fitness (e.g., physiology, behavior, reproductive potential). Invertebrates in the Study Area could potentially be impacted by introduction of invasive species due to direct predation, competition for prey, or displacement from suitable habitat. Invasive species could be introduced by growth on vessel hulls or discharges of bilge water. Refer to Section 3.2.1.2.2 (Federal Standards and Guidelines) for a discussion of naval vessel discharges.

There are generally two ways that a marine invertebrate could be exposed to multiple additive stressors. The first would be if an invertebrate were exposed to multiple sources of stress from a single event or activity within a single testing or training event (e.g., a mine warfare event may include the use of a sound source and a vessel). The potential for a combination of these impacts from a single activity would depend on the range to effects of each of the stressors and the response or lack of response to that stressor. Most of the activities proposed under Alternative 1 generally involve the use of moving platforms (e.g., ships, torpedoes) that may produce one or more stressors; therefore, if invertebrates were within the potential impact range of those activities, they may be impacted by multiple stressors simultaneously. Individual stressors that would otherwise have minimal to no impact, may combine to have a measurable response. However, due to the wide dispersion of stressors, speed of the platforms, and general dynamic movement of many training and testing activities, it is unlikely that a pelagic or mobile marine invertebrate would occur in the potential impact range of multiple sources or sequential exercises. Impacts would be more likely to occur to sessile and slow-moving species, and in areas where training and testing activities are concentrated (e.g., in the vicinity of Naval Stations Norfolk and Mayport, the gunnery box in the Jacksonville Range Complex, the Undersea Warfare Training Range, and the Naval Surface Warfare Center, Panama City Division and Naval Undersea Warfare Center Division, Newport Testing Ranges).

Secondly, an invertebrate could be exposed to multiple training and testing activities over the course of its life. It is unlikely that mobile or migratory marine invertebrates that occur within the water column would be exposed to multiple activities during their lifespan because they are relatively short-lived, and most Navy training and testing activities impact small, widely-dispersed areas, often during the day when many pelagic invertebrates have migrated away from the surface. It is much more likely that stationary organisms or those that only move over a small range (e.g., corals, sponges, worms, and sea urchins) would be exposed to multiple stressors for a prolonged duration. A few activities occur at a fixed point (e.g., port security training, pierside sonar testing), and could potentially affect the same sessile or sedentary individual invertebrates. However, due to invertebrate distribution and lifespan, few individuals compared to overall population size would likely be affected repeatedly by the same stressor, and the impacts would be mostly non-lethal. Other Navy activities may occur in the same general area (e.g., gunnery activities), but do not occur at the same specific point each time and would therefore be unlikely to affect the same individual invertebrates.

Multiple stressors may also have synergistic effects. For example, although it has been suggested that military activities may contribute to coral decline, global impacts are driven primarily by synergistic impacts of pollution, overfishing, climate change, sedimentation, and naturally occurring stressors such as predator outbreaks and storms, among other factors (Ban et al., 2014; Muthukrishnan & Fong, 2014). As discussed in the analyses above, marine invertebrates are not particularly susceptible to energy, entanglement, or ingestion stressors resulting from Navy activities; therefore, the potential for Navy stressors to result in additive or synergistic consequences is most likely limited to acoustic, physical strike and disturbance, and secondary stressors. The potential synergistic interactions of multiple stressors resulting from Navy activities are difficult to predict quantitatively. Even for shallow-water corals, an exceptionally well-studied resource, predictions of the consequences of multiple stressors are semi-quantitative and generalized predictions remain qualitative (Hughes & Connell, 1999; Norstrom et al., 2009).

Although potential impacts on marine invertebrate species from training and testing activities under Alternative 1 may include injury and mortality, in addition to other effects such as physiological stress, masking, and behavioral effects, the impacts are not expected to lead to long-term consequences for invertebrate populations or subpopulations. The number of invertebrates impacted is expected to be small relative to overall population sizes, and would not be expected to yield any lasting effects on the survival, growth, recruitment, or reproduction of any invertebrate species. The potential impacts anticipated on ESA-listed species from Alternative 1 are summarized in Section 3.4.5 (Endangered

Species Act Determinations). For a discussion of cumulative impacts, see Chapter 4 (Cumulative Impacts). For a discussion of mitigation, see Chapter 5 (Mitigation).

3.4.4.2 Combined Impacts of All Stressors Under Alternative 2

Training and testing activities proposed under Alternative 2 would represent an increase over what is proposed for Alternative 1. However, these minor differences are not expected to substantially increase the potential for impacts over what is analyzed for Alternative 1. The analysis presented in Section 3.4.4.1 (Combined Impacts of All Stressors Under Alternative 1) would similarly apply to Alternative 2. The combined impacts of all stressors for training and testing activities under Alternative 2 are not expected to lead to long-term consequences for invertebrate populations or subpopulations. The number of invertebrates impacted is expected to be small relative to overall population sizes and would not be expected to yield any lasting effects on the survival, growth, recruitment, or reproduction of any invertebrate species.

3.4.4.3 Combined Impacts of All Stressors Under the No Action Alternative

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

3.4.5 Endangered Species Act Determinations

Pursuant to the ESA, the Navy has concluded training and testing activities may affect the boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, and staghorn coral. The Navy has also concluded that training and testing activities may affect designated critical habitat for elkhorn coral and staghorn coral. The Navy has consulted with NMFS as required by section 7(a)(2) of the ESA in that regard. The Navy's summary of effects determinations for each ESA-listed species is shown in Table 3.4-3. Where the effects determinations reached by NMFS in their Biological Opinion differed from the Navy's, those differences are noted in a footnote to Table 3.4-3. NMFS determinations are made on the overall Proposed Action and are not separated by training and testing activities.

Table 3.4-3: Invertebrate Effect Determinations for Training and Testing Activities Under Alternative 1 (Preferred Alternative)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explo-sives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Training Activities																			
Boulder star coral	Throughout range	NE[1]	N/A	NE	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE[1]
Elkhorn coral	Throughout range	NE[1]	N/A	NE	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE[1]
	Critical habitat	NE	N/A	NE	NE	NE	NE	NLAA	NE	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE
Lobed star coral	Throughout range	NE[1]	N/A	NE	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE[1]
Mountainous star coral	Throughout range	NE[1]	N/A	NE	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE[1]
Pillar coral	Throughout range	NE[1]	N/A	NE	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE[1]
Rough cactus coral	Throughout range	NE[1]	N/A	NE	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE[1]
Staghorn coral	Throughout range	NE[1]	N/A	NE	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE[1]
	Critical habitat	NE	N/A	NE	NE	NE	NE	NLAA	NE	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	N/A	NE	NE

Table 3.4-3: Invertebrate Effect Determinations for Training and Testing Activities Under Alternative 1 (Preferred Alternative) (continued)

Species	Designation Unit	*Effect Determinations by Stressor*																	
		Acoustic						*Explo-sives*	*Energy*		*Physical Disturbance and Strike*				*Entanglement*			*Ingestion*	
		Sonar and Other Transducers	*Air Guns*	*Pile Driving*	*Vessel Noise*	*Aircraft Noise*	*Weapons Noise*	*Explosives*	*In-water Electromagnetic Devices*	*High-energy Lasers*	*Vessels*	*In-water Devices*	*Military Expended Materials*	*Seafloor Devices*	*Wires and Cables*	*Decelerators/Parachutes*	*Biodegradable Polymer*	*Military Expended Materials - Munitions*	*Military Expended Materials - Other Than Munitions*
Testing Activities																			
Boulder star coral	Throughout range	NE[1]	NE	N/A	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE[1]
Elkhorn coral	Throughout range	NE[1]	NE	N/A	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE[1]
	Critical habitat	NE	NE	N/A	NE	NE	NE	NLAA	NE	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE
Lobed star coral	Throughout range	NE[1]	NE	N/A	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE[1]
Mountainous star coral	Throughout range	NE[1]	NE	N/A	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE[1]
Pillar coral	Throughout range	NE[1]	NE	N/A	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE[1]
Rough cactus coral	Throughout range	NE[1]	NE	N/A	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE[1]
Staghorn coral	Throughout range	NE[1]	NE	N/A	NE[1]	NE	NE	NLAA	NE[1]	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE[1]
	Critical habitat	NE	NE	N/A	NE	NE	NE	NLAA	NE	NE	NE[1]	NE	NLAA[2]	NLAA	NE[2]	NE	NE[2]	NE	NE

Note: NE = no effect; NLAA = may effect, not likely to adversely affect; LAA = may effect, likely to adversely affect; N/A = not applicable, activity related to the stressor does not occur during specified training or testing events (e.g., there are no testing activities that involve the use of pile driving).
[1] Based on the analysis conducted in the Biological Opinion, NMFS reached the determination of NLAA.
[2] Based on the analysis conducted in the Biological Opinion, NMFS reached the determination of LAA.

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

TABLE OF CONTENTS

List of Figures

List of Tables

3.5 HABITATS

HABITATS SYNOPSIS

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

- Acoustics: Acoustic stressors are not applicable to habitats, due to the fact that habitats do not have hearing capabilities, and are not analyzed in this section.
- Explosives: Most explosives would detonate in air or at or near the water surface. Some explosives would be placed on the bottom. Explosive detonations on or near the bottom would produce percussive energy that could impact bottom habitat. While hard bottom would mostly reflect the energy, a crater would form in soft bottom. On substrates other than clay, the effects would be temporary, whereas craters in clay may be persistent. Craters in soft bottom, where substrate moves around with the tides and currents, would only last for days to weeks. The surface area of bottom substrate affected would be a tiny fraction of the total training and testing area available in the Study Area.
- Energy: Energy stressors are not applicable to habitats because of the lack of sensitivity of habitats and are not analyzed in this section.
- Physical Disturbance and Strike: Most seafloor devices would be placed in areas that would result in minor and temporary bottom substrate impacts. Once on the seafloor and over time, military expended material would be buried by sediment, corroded from exposure to the marine environment, or colonized by benthic organisms. The surface area of bottom substrate affected over the short-term would be a tiny fraction of the total training and testing area available in the Study Area.
- Entanglement: Entanglement stressors are not applicable because habitats do not have the ability to become "entangled" by materials. The potential for expended material to cover a substrate is discussed under the physical disturbance and strike stressor.
- Ingestion: Ingestion stressors are not applicable because habitats lack the ability to ingest; therefore, ingestion stressors are not analyzed for habitats.
- Secondary stressors: Secondary stressors are not applicable to habitats, as they are not susceptible to impacts from secondary stressors, and are not analyzed further in this section.

3.5.1 INTRODUCTION

This chapter provides the analysis of potential impacts on marine and estuarine non-living (abiotic) substrates found in the Atlantic Fleet Training and Testing (AFTT) Study Area (Study Area). This section provides an introduction to the abiotic habitats that occur in the Study Area. The following sections describe the abiotic habitats in greater detail (Section 3.5.2, Affected Environment) and evaluate the potential impacts of testing and training activities on abiotic habitats (Section 3.5.3, Environmental Consequences). A summary of the potential impacts on abiotic habitats for each alternative is provided in Section 3.5.4 (Summary of Potential Impacts on Habitats).

The Study Area covers a range of marine and estuarine habitats, each supporting communities of organisms that may vary by season and location. The intent of this section is to cover abiotic habitat features and impacts that are not addressed in the individual living resources chapters. The water column and bottom substrate provide the necessary habitats for living resources, including those that form biotic habitats such as aquatic plant beds and coral reefs, which are discussed in other sections (e.g., Section 3.3, Vegetation; Section 3.4, Invertebrates). The potential for training or testing to impact the chemical quality of abiotic habitat is addressed in a separate chapter (Section 3.2, Sediments and Water Quality). Potential impacts to organisms and biotic habitats are covered in their respective resource sections. Potential impacts to the water column are not addressed in this section, because the effects would not be associated with a change in habitat type but rather would be limited to changes in water quality, which are addressed in Section 3.2 (Sediments and Water Quality). Further, the water column is discussed as a type of Essential Fish Habitat in the Navy's Essential Fish Habitat Assessment (U.S. Department of the Navy, 2018b, 2018c); a summary of the assessment can be found in Section 6.1.3 (Magnuson-Stevens Fishery Conservation and Management Act). Acoustic energy transmitting through the water column may temporarily affect the suitability of the water column as habitat for certain species of invertebrates, fish, marine mammals, and sea turtles. The potential effects on species that use the water column as habitat are addressed in those specific resource sections (e.g., Section 3.4, Invertebrates; Section 3.6, Fishes; Section 3.7, Marine Mammals; Section 3.8, Reptiles). Therefore this section only addresses impacts to habitat substrate.

Table 3.5-1 presents the types of habitats discussed in this section in relation to the open ocean areas; large marine ecosystems; and bays, estuaries, and rivers in which they occur. Habitat types are derived from *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al., 1979), which includes a basic classification of intertidal shores, subtidal bottoms, and associated substrates. Whereas there are many classification systems spanning a range of spatial dimensions and granularity (Allee et al., 2000; Cowardin et al., 1979; Howell et al., 2010; Kendall et al., 2001; United Nations Educational Scientific and Cultural Organization, 2009; Valentine et al., 2005), there are basically three types of abiotic substrates based on the grain size of unconsolidated material: "soft bottom" (e.g., sand, mud), "intermediate" (e.g., cobble, gravel), and "hard bottom" (e.g., bedrock, boulders).

Spatial and temporal variation in abiotic substrate is created by the interplay of underlying geology, currents, and water quality at a location. The classification system provided in Table 3.5-1 starts at the subsystem level (e.g., intertidal shores and subtidal bottoms) and focuses analysis on a modified class level (e.g., soft shores/bottoms, intermediate shores/bottoms, hard shores/bottom). The listed subsystems and classes refer to non-living substrates and are differentiated from living structures on the substrate. Living structures on the substrate are termed biotic habitats, and include wetland shores, aquatic plant beds (e.g., attached macroalgae, rooted vascular plants), sedentary invertebrate beds, and reefs (e.g., corals, oysters).

The physical characteristics of substrates, whether they are unconsolidated and soft or hard and rocky, are key factors in structuring sedentary biological communities (Nybakken, 1993). Physical characteristics of the different substrate types represent a viable target for the best available mapping technology (i.e., multibeam sonar) and are useful for characterizing Navy impacts (e.g., explosive charges on soft bottom).

Table 3.5-1: Habitat Types Within the Large Marine Ecosystems and Open Ocean of the Atlantic Fleet Training and Testing Study Area

Substrate Type	*Subtypes (Examples)*	*Open Ocean*	*Large Marine Ecosystems*	*Bays, Estuaries, and Rivers*
Intertidal Shores				
Soft Shores	Beach, tidal delta/flat	–	All	All
Intermediate Shores	Cobble/gravel, mixed	–	Northeast U.S. Continental Shelf	All
Hard Shores	Rocky intertidal	–	Northeast U.S. Continental Shelf, Caribbean Sea	Bath, ME; Portsmouth Naval Shipyard; Kittery, ME; coastal southern New England waters; Naval Submarine Base New London; Groton, CT
Subtidal Bottoms				
Soft Bottoms	Channel, flat, shoal	All	All	All
Intermediate Bottom	Cobble/gravel, mixed	All	All	All
Hard Bottom	Rocky subtidal	All	All	All
Intertidal Shore or Subtidal Bottom				
Artificial Structures	Artificial reefs, ship wrecks, oil/gas platforms, bulkheads, and piers	All	All	All

Differences among the physical and chemical environments of various abiotic habitats dictate both the variety and abundance of sessile marine organisms supported. The assessment in this section focuses on the potential for testing or training activities to change or modify the physical properties of abiotic substrates and their ecological functions as habitat for organisms. A physical impact on abiotic marine habitats is anticipated where training or testing activities have the potential to displace sediment, convert one substrate type into another (e.g., bedrock to unconsolidated soft bottom), alter vertical relief, or modify structural complexity.

3.5.2 Affected Environment

3.5.2.1 General Background

Abiotic marine habitats vary according to geographic location, underlying geology, hydrodynamics, atmospheric conditions, and suspended particles and associated biogenic features. Sediments may be derived from material eroded from land sources associated with coastal bluff erosion and sediment flows from creeks and rivers, which may create channels, tidal deltas, intertidal and subtidal flats, and shoals of unconsolidated material along the shorelines and estuaries.

The influence of land-based nutrients on habitat type and sediment increases with proximity to streams, bays and harbors, and nearshore waters. In the open ocean, gyres, eddies, and oceanic currents influence the distribution of organisms. Major bottom features in the offshore areas of large marine ecosystems include shelves, banks, breaks, slopes, canyons, plains, and seamounts. Geologic features such as these affect the hydrodynamics of the ocean water column (i.e., currents, gyres, upwellings) as well as living resources present. Bathymetric features of the Study Area are described in Section 3.0.2.2 (Bathymetry). The distribution of abiotic marine habitats among the large marine ecosystems and open ocean areas is described in their respective subsections below.

The majority of the Study Area lies outside of state waters. State waters extend from shore to 3 nautical miles (NM) throughout the Study Area, with the exception of the Gulf coast of Florida, Texas, and Puerto Rico, where state waters extend 9 NM offshore. Therefore, relatively little of the Study Area includes intertidal and shallow subtidal areas in state waters where numerous habitats are exclusively present (e.g., salt/brackish marsh, mangrove, seagrass beds, kelp forests, oyster reefs). Intertidal abiotic habitats (i.e., beaches, tidal deltas, mudflats, rocky shores) represent only a small portion of the Study Area; however, they are addressed along with all other habitats (where those habitats overlap with naval training or testing activities).

3.5.2.1.1 Shore Habitats

3.5.2.1.1.1 Description

Soft Shores

Soft shores include all aquatic habitats that have three characteristics: (1) unconsolidated substrates with less than 25 percent areal cover of stones, boulders, or bedrock; (2) unconsolidated sediment composed of predominantly sand or mud; and (3) primarily intertidal water regimes (Cowardin et al., 1979). Note that a shoreline covered in vegetation (e.g., marsh) could still have a soft substrate foundation. Soft shores include beaches, tidal flats/deltas, and streambeds of the tidal riverine and estuarine systems.

Intermittent or intertidal channels of the riverine system and intertidal channels of the estuarine system are classified as streambed. Intertidal flats, also known as tidal flats or mudflats, consist of loose mud, silt, and fine sand, with organic-mineral mixtures, and are regularly exposed and flooded by the tides (Karleskint et al., 2006). Muddy and fine sediment tends to be deposited where wave energy is low, such as in sheltered bays and estuaries (Holland & Elmore, 2008). Mudflats are typically unvegetated, but may be covered with encrusting microscopic algae (e.g., diatoms) or sparsely vegetated with low-growing aquatic plants (e.g., macroalgae/seaweed, seagrass). Muddy intertidal habitat occurs most often as part of a patchwork of intertidal habitats that may include rocky shores, tidal creeks, sandy beaches, salt marshes, and mangroves. A flat area of unconsolidated sediment that is covered in aquatic plants could be considered an aquatic bed growing on soft shore habitat. While river deltas are created by soil deposits forming from the outflow of the water, such as at the mouth of the Mississippi River, tidal deltas are depositions of sediment left by the diurnal tides and their resulting currents. Therefore, tidal (or tide-dominated) deltas typically occur in locations of large tidal ranges or high tidal current speeds (SEPM Strata, 2018).

Beaches form through the interaction of waves and tides, as particles are sorted by size and are deposited along the shoreline (Karleskint et al., 2006). Wide flat beaches with fine-grained sands occur where wave energy is limited. Narrow steep beaches of coarser sand form where energy and tidal ranges are high (Speybroeck et al., 2008). Three zones characterize beach habitats: (1) dry areas above mean high water, (2) wrack lines (the area where seaweed and debris is deposited at high tide), and (3) a high-energy intertidal zone (area between high and low tide).

Intermediate Shores

Intermediate shores include all aquatic habitats with the following three characteristics: (1) substrates with at least 25 percent cover in particles smaller than stones; (2) unconsolidated substrate is predominantly gravel or cobble-sized; and (3) primarily intertidal water regimes. These areas may or may not be stable enough for attached vegetation or invertebrates, depending on overlying hydrology and water quality. Note that a shoreline covered in vegetation (e.g., macroalgae/seagrass) could still have an intermediate substrate foundation.

Hard Shores

Rocky shores include intertidal aquatic habitats characterized by bedrock, stones, and boulders that cover 75 percent or more of an area (Cowardin et al., 1979). Note that a shoreline covered in vegetation could still have a hard substrate foundation. Rocky intertidal shores are areas of bedrock occupying the area between high and low tide lines (Menge & Branch, 2001). Extensive rocky shorelines can be interspersed with sandy areas, estuaries, or river mouths.

Environmental gradients between hard shorelines and subtidal habitats are determined by wave action, depth, frequency of tidal inundation, and stability of substrate (Cowardin et al., 1979). Where wave energy is extreme, only rock outcrops may persist. In lower energy areas, a mixture of rock sizes will occur in the intertidal zone. Boulders scattered in the intertidal provide substrate for attached macroalgae and sessile invertebrates.

3.5.2.1.1.2 Distribution

Soft Shores

Mudflats occur to some extent in virtually every large marine ecosystem within the Study Area. Muddy deposits accumulate in many wave-protected pockets on the Gulf of Maine coast along the northern part of the Northeast United States (U.S.) Continental Shelf Large Marine Ecosystem, especially at the heads of bays. Extensive mudflats occur in the upper reaches of the Bay of Fundy. In the Southeast U.S. Continental Shelf Large Marine Ecosystem, mudflats are most often associated with tidal creeks and estuaries. In the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems, salt marshes and tidal creeks occur along the coastal margins behind barrier islands. Mudflats associated with mangroves occur on the east coast of Florida, roughly from St. Augustine to the Florida Keys, and north to Cedar Key on the west coast of Florida in the southern part of the Southeast U.S Continental Shelf Large Marine Ecosystem. Tidal deltas and intertidal flats are present along the coast of Puerto Rico and Vieques (National Ocean Service, 2011).

Sandy beaches are less abundant but do occur in the northern part of the Northeast U.S. Continental Shelf Large Marine Ecosystem, which are otherwise dominated by rocky coasts. Small pocket beaches occur within the northern Gulf of Maine, and sandy beaches are abundant on Cape Cod in the southern Gulf of Maine. Some sandy intertidal habitats occur in all the states and provinces on the Gulf of Maine coast.

The Mid- and South Atlantic coast region is protected by an almost continuous string of barrier islands, which provide sandy intertidal shores (National Ocean Service, 2011). Sandy coasts and barrier islands are common from Long Island, New York to as far south as Florida. A long arc of barrier islands known as the Outer Banks protects the shore from southeastern Virginia almost to South Carolina.

Sandy intertidal habitat predominates in the Southeast U.S. Continental Shelf Large Marine Ecosystem. The east and west coasts of Florida have long stretches of sandy beaches. The West Central Barrier Chain, a series of sandy barrier islands, stretches from Anclote Key (north of Tampa Bay) south to Cape Romano (near Naples) and protects the west coast of Florida. Sandy beaches are present along the shoreline of Puerto Rico and Vieques.

The eastern portion of the Gulf of Mexico Large Marine Ecosystem is fringed by sandy intertidal habitat, including barrier islands off the coast of the Florida panhandle. Shorelines of the western portion of the Gulf of Mexico Large Marine Ecosystem are dominated by sand that forms broad straight beaches and barrier islands (Britton & Morton, 1998). The longest undeveloped barrier island in the world is Padre Island National Seashore in Texas, which has 70 miles of sand beaches that provide nesting ground for sea turtles, foraging ground for shorebirds, and sandy intertidal habitat for numerous other species (National Park Service, 2010). Other barrier islands continue in an arc, trending up the Texas coast (Mustang, San Jose, Matagorda, Follets, and Galveston Islands) (Britton & Morton, 1998).

Intermediate Shores

Most of the intermediate coastline of the U.S. Atlantic coast occurs in the transitional area of the Northeast U.S. Continental Shelf Large Marine Ecosystem where the mostly consolidated rocky shores primarily off of Maine give way to the sandy shores in the south (Roman et al., 2000). On the U.S. Atlantic shore, intermediate rocky and gravelly areas do not typically occur south of New York (National Ocean Service, 2011).

Hard Shores

Most of the rocky coastline of the U.S. Atlantic coast occurs from Massachusetts northward into the Gulf of Maine, in the northern part of the Northeast U.S. Continental Shelf Large Marine Ecosystem (Roman et al., 2000). Glacial terrain made of bedrock, gravel, and sediment typical of the New England coast is unique on the east coast of the United States. Rocky shorelines border training or testing activities originating from the shipyard in Bath, Maine; Portsmouth Naval Shipyard (Kittery, Maine); coastal southern New England waters; and the shipyard and Naval Submarine Base New London (Groton, Connecticut). On the U.S. Atlantic shore, rocky and gravelly areas do not typically occur south of New York (National Ocean Service, 2011). Rocky coasts in the northern areas give way to intermediate or mixed shores and sandy shores toward the south. In the Southeast U.S. Continental Shelf Large Marine Ecosystem, sandy beaches predominate. In the Caribbean Sea, rocky bedrock shorelines are mapped along the coast of Puerto Rico and Vieques (National Ocean Service, 2011). Very little hard shores habitat occurs anywhere in the northern Gulf of Mexico.

3.5.2.1.2 Bottom Habitats

3.5.2.1.2.1 Description

Soft Bottom

Soft bottoms include all aquatic habitats with the following three characteristics: (1) at least 25 percent cover of particles smaller than stones, (2) unconsolidated sediment is predominantly mud or sand, and (3) primarily subtidal water regimes (Cowardin et al., 1979). Soft bottom forms the substrate of channels, shoals, subtidal flats, and other features of the bottom. Sandy channels emerge where strong currents connect estuarine and ocean water columns. Shoals or capes form where sand is deposited by interacting, sediment-laden currents. Subtidal flats occur between soft shores and channels or shoals. The continental shelf extends seaward of the shoals and inlet channels and includes relatively coarse-grained, soft bottom habitats. Relatively finer-grained sediments collect off the shelf break, continental slope, and abyssal plain. Organisms characteristic of soft bottom environments, such as worms and clams, may be found at all depths where there is sufficient oxygen and sediment accumulation (Nybakken, 1993).

Intermediate Bottom

Intermediate bottom includes all aquatic habitats with the following three characteristics: (1) substrates with at least 25 percent cover in particles smaller than stones, (2) unconsolidated substrate is predominantly gravel or cobble-sized, and (3) primarily subtidal water regimes. These areas may or may not be stable enough for attached vegetation or sedentary invertebrates, depending on overlying hydrology and water quality.

Hard Bottom

Hard bottom includes all aquatic habitats with substrates having a surface of stones, boulders, or bedrock (75 percent or greater coverage) (Cowardin et al., 1979). Subtidal rocky habitat occurs as extensions of intertidal rocky shores and as isolated offshore outcrops. The shapes and textures of the larger rock assemblages and the fine details of cracks and crevices are determined by the type of rock, the wave energy, and other local variables (Davis, 2009). Maintenance of mostly low-relief hard bottom (e.g., bedrock) requires wave energy and/or currents sufficient to sweep sediment away (Lalli & Parsons, 1993) or offshore areas lacking a significant sediment supply; therefore, rocky reefs are rare on broad coastal plains near sediment-laden rivers and are more common on high-energy shores and beneath strong bottom currents, where sediments cannot accumulate.

In the deep waters of the Atlantic Ocean and Gulf of Mexico, there are also a number of chemosynthetic communities (cold seeps and thermal vents), which tend to support unique biotic communities. A cold seep, or cold vent, is an area of the ocean floor where chemical fluid seepage occurs. Cold seeps develop unique topography over time, where reactions between methane and seawater create carbonate rock formations and reefs. A thermal, or hydrothermal, vent is a fissure in the seafloor where geothermally heated water is released. Hard substrate in the abyssal zone and some locations landward of the deep ocean are virtually devoid of encrusting or attached organisms due to the scarcity of drifting food particles in the deep ocean (Nybakken, 1993). Exceptions are areas on seamounts and along the Mid-Atlantic Ridge where chemosynthetic communities occur (see Section 3.4, Invertebrates, for additional information).

3.5.2.1.2.2 Distribution

Soft, intermediate, and hard bottom habitats occur in all large marine ecosystems and the open ocean. However, the distribution of different bottom types varies across the Study Area (Figure 3.5-1 through Figure 3.5-4) and is depicted by over 25 datasets. These datasets were ranked by quality and assembled into a non-overlapping mosaic as described in *Building and Maintaining a Comprehensive Database and Prioritization Scheme for Overlapping Habitat Data* (U.S. Department of the Navy, 2018a). The datasets employ a variety of data collection and analysis techniques to characterize the seafloor; results are summarized below. Thousands of acres of lower quality data were superseded by high quality data in the process of creating the non-overlapping abiotic substrate maps for the AFTT Study Area.

Most of the bottom within the Study Area (approximately 80 percent) has not been mapped. However the majority of the unmapped portion is seaward of the U.S. continental shelf in the Atlantic Basin/abyssal zone (Table 3.5-2). Available mapping for abiotic substrate indicates a benthic surface composed of mostly soft bottom (less than 86 percent) with a little over 6 percent hard bottom, adjusted qualitatively for over- or underestimation. The intermediate category of substrate (8 percent) could add to either the soft bottom or hard bottom type, depending on other environmental variables affecting stability and the supply of colonizing sedentary organisms and their nutrient sources, which also affect hard substrate as a habitat for hard bottom organisms (to a lesser degree). It should be noted that the percent of bottom area stated above for each habitat type does not account for the vertical relief of some hard bottom areas, which contribute disproportionately to hard bottom community biomass. The data also do not account for small hard bottom features that may be present in predominantly soft bottom areas; trawl sampling results used to develop the Southeast Area Monitoring and Assessment Program – South Atlantic (Southeast Area Monitoring and Assessment Program—South Atlantic, 2001) line data suggest there were numerous hard bottom features too small to be resolved by even the highest quality data in the Study Area. U.S. Department of the Navy (2011) data and classification came the closest to finding these smaller areas of hard bottom and associated invertebrate species.

Table 3.5-2: Percent Coverage of Abiotic Substrate Types in Large Marine Ecosystems and the Open Ocean Areas of the AFTT Study Area

Large Marine Ecosystem and Open Ocean Areas	*Percent of Large Marine Ecosystem*				*Total Acres*
	Hard	*Intermediate*	*Soft*	*Unknown*	
Caribbean Sea	9.65%	0.82%	15.67%	73.86%	32,561,898
Gulf of Mexico	3.46%	3.70%	64.71%	28.12%	388,295,532
Gulf Stream	4.91%	1.60%	20.76%	72.73%	31,139,231
Labrador Current	0.00%	0.00%	0.00%	100.00%	268,386,453
Newfoundland-Labrador Shelf	0.00%	0.00%	0.00%	100.00%	151,841,151
Northeast U.S. Continental Shelf	6.22%	28.26%	65.38%	0.14%	69,423,078
North Atlantic Gyre	0.00%	0.00%	1.92%	98.08%	1,383,112,689
Scotian Shelf	0.04%	1.69%	6.10%	92.16%	39,949,139
Southeast U.S. Continental Shelf	19.85%	10.22%	69.73%	0.20%	66,369,903
West Greenland Shelf	0	0	0	100	12,959,689
Grand Total	4.90%	5.14%	27.14%	62.81%	2,444,038,763

Soft Bottom

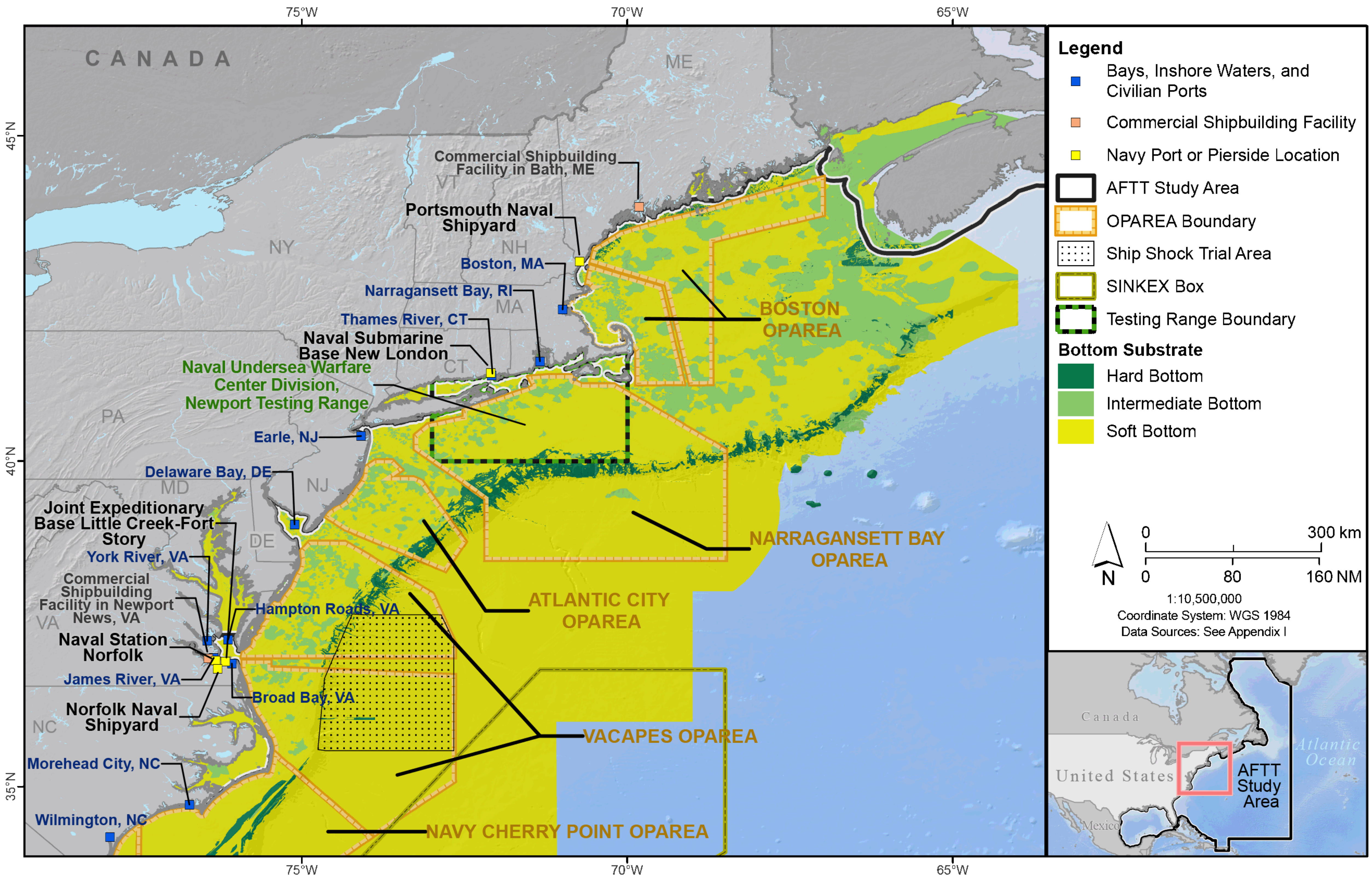
Soft bottom is the largest habitat type within mapped portions of the Study Area and occurs in all large marine ecosystems and the open ocean. Soft bottom habitat is depicted in Figure 3.5-1 through Figure 3.5-4, based on over 25 datasets (U.S. Department of the Navy, 2018a).

Intermediate Bottom

Intermediate bottoms occur in all large marine ecosystems and the open ocean and are depicted in Figure 3.5-1 through Figure 3.5-4 by at least eight datasets (U.S. Department of the Navy, 2018a).

Hard Bottom

Hard bottoms occur in all large marine ecosystems and the open ocean, and are depicted in Figure 3.5-1 through Figure 3.5-4 based on at least eight datasets (U.S. Department of the Navy, 2018a).



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

Figure 3.5-1: Bottom Types Within the Northeast U.S. Continental Shelf Large Marine Ecosystem and Open Ocean Areas

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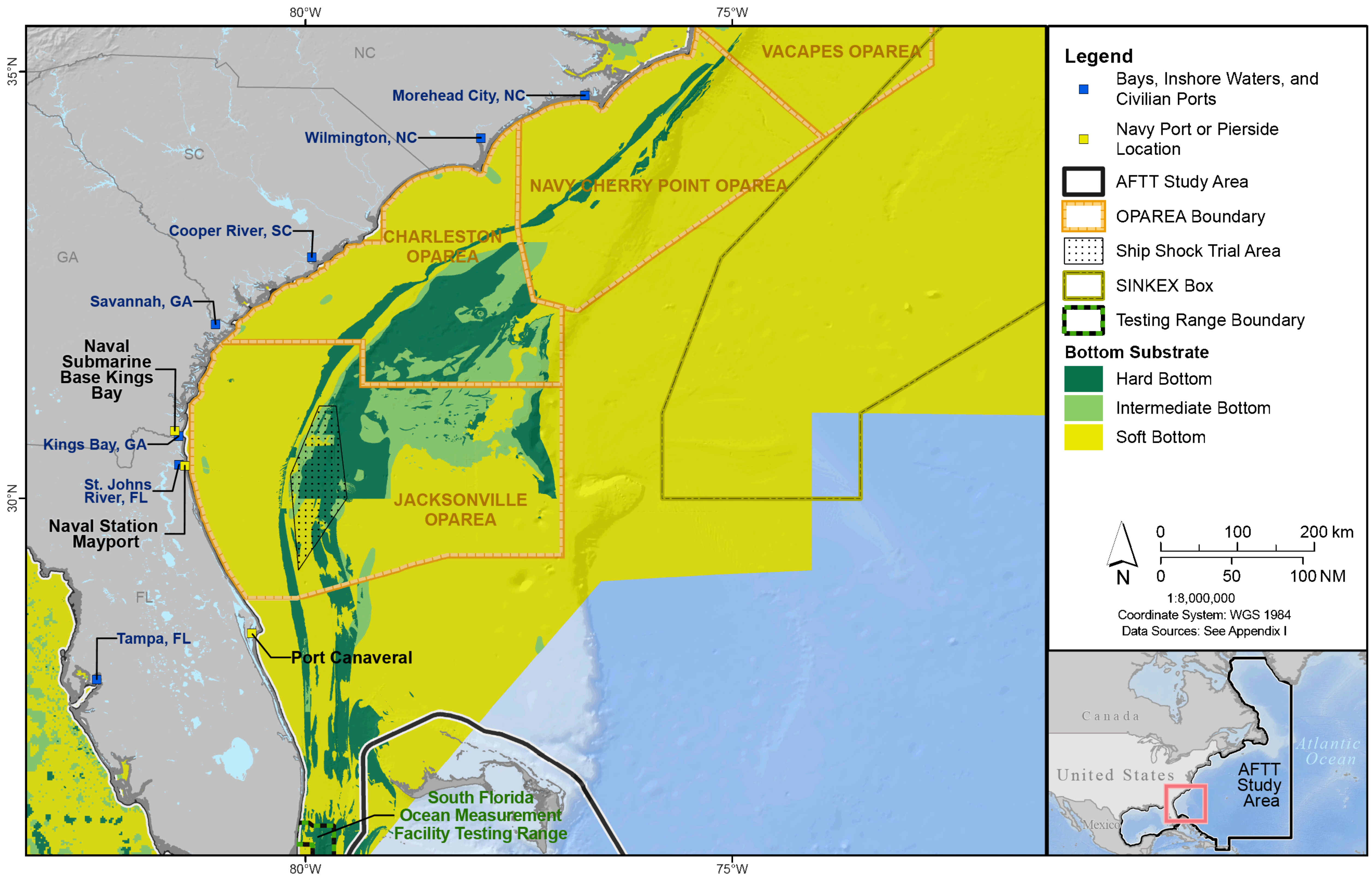

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.5-2: Bottom Types Within the Southeast U.S. Continental Shelf Large Marine Ecosystem and Open Ocean Areas

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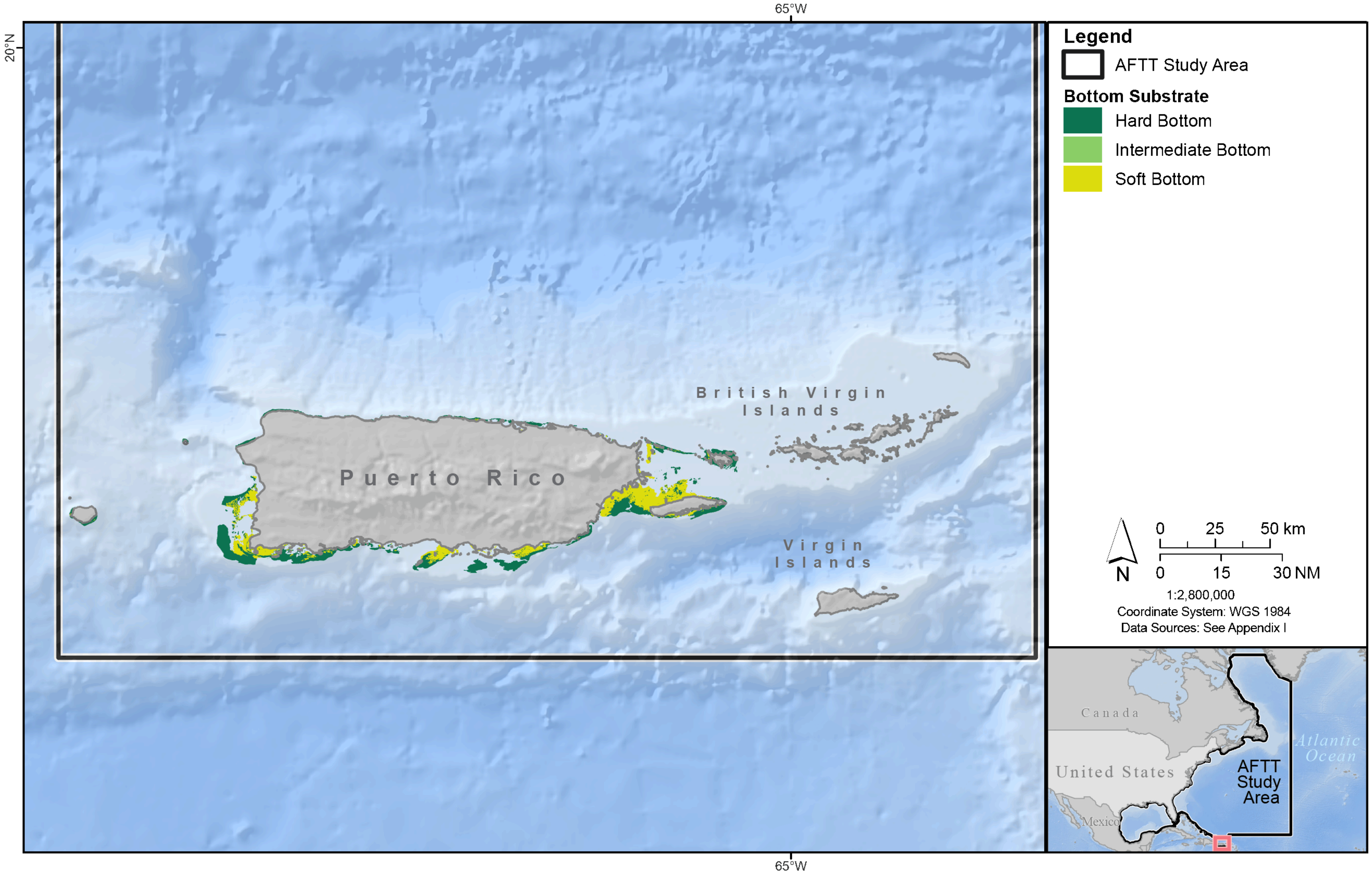

Notes: AFTT: Atlantic Fleet Training and Testing

Figure 3.5-3: Bottom Types Within the Caribbean Sea Large Marine Ecosystem

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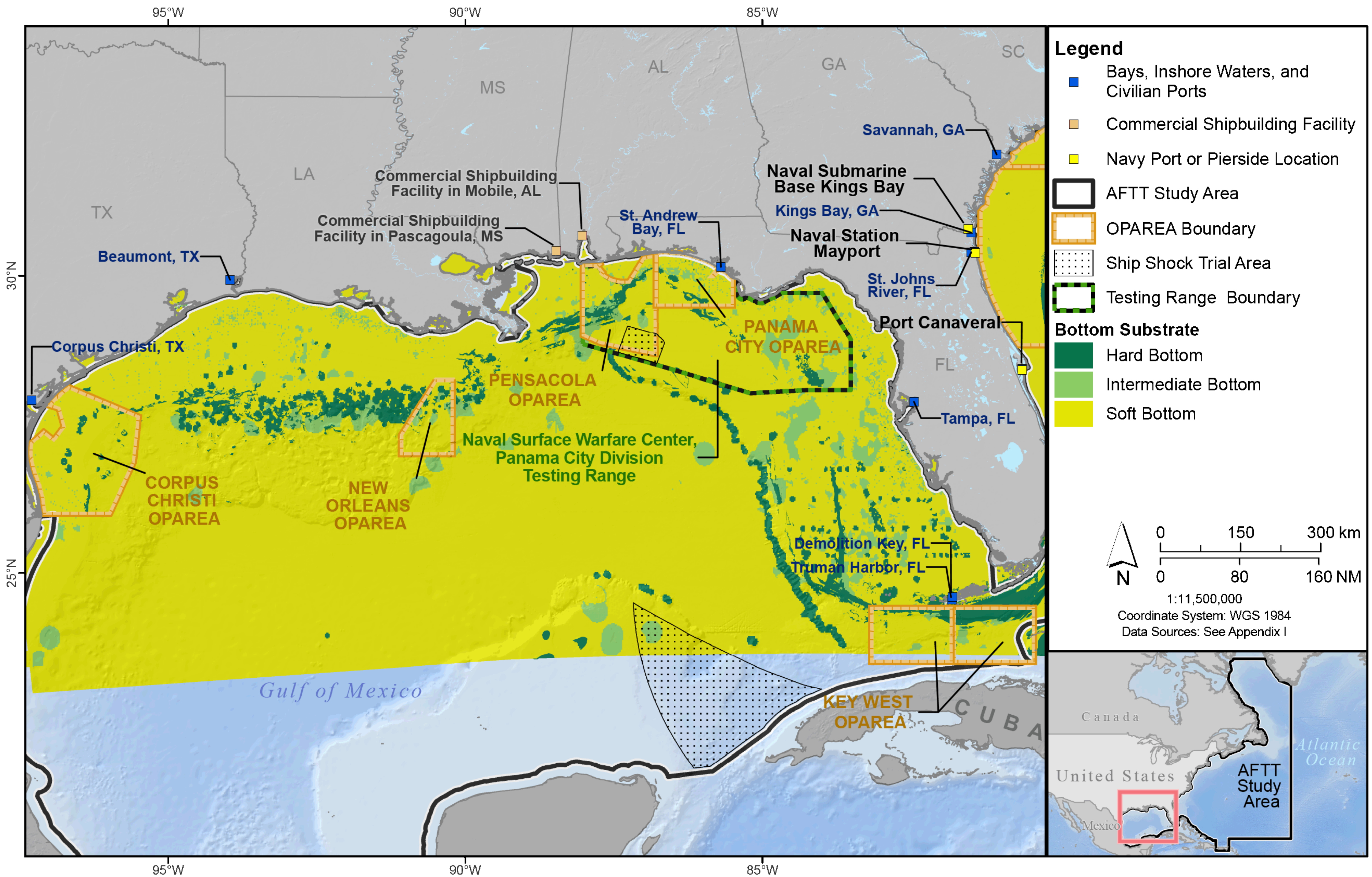

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area

Figure 3.5-4: Bottom Types Within the Gulf of Mexico Large Marine Ecosystem

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3.5.2.1.3 Artificial Structures

3.5.2.1.3.1 Description

Man-made structures that are either deliberately or unintentionally submerged underwater create artificial habitats that mimic some characteristics of natural habitats, such as providing hard substrate and vertical relief (Broughton, 2012). Artificial reef habitats have been intentionally created with material from sunken ships, rock and stone, concrete and rubble, car bodies, tires, scrap metal, and various other materials. Artificial habitats also have been created as a result of structures built for other purposes (e.g., breakwaters, jetties, piers, wharves, bridges, oil and gas platforms, fish aggregating devices) or unintentional sinking of vessels (i.e., shipwrecks).

Some artificial structures provide ecological functions similar to natural hard bottom habitats, such as providing attachment substrate for algae and sessile invertebrates, which in turn supports a community of mobile organisms that may forage, shelter, and reproduce there (National Oceanic and Atmospheric Administration, 2007). Other structures may or may not support sessile organisms and only temporarily attract mobile organisms. Factors such as the materials, structural features, and surface area of the artificial substrate, as well as local environmental conditions, influence the variety and abundance of sessile organisms that may become established and the relative success of attracting or enhancing local fish populations (Ajemian et al., 2015; Broughton, 2012; Macreadie et al., 2011; Powers et al., 2003; Ross et al., 2016).

Artificial habitats in the Study Area include artificial reefs, shipwrecks, oil and gas platforms, man-made shoreline structures (e.g., piers, wharfs, docks, pilings), and obsolete military towers used for aircraft training (Macfadyen et al., 2009; Seaman, 2007; U.S. Department of the Navy, 2018a). Artificial reefs are designed and deployed to supplement the ecological services provided by coral or rocky reefs. Artificial reefs range from simple concrete blocks to highly engineered structures. Vessels that are unintentionally sunk in the Study Area may be colonized by encrusting and attached marine organisms if there is a larval source and enough nutrition (e.g., detritus) drifting through the water column. Wrecks in the deep ocean and some locations landward of the deep ocean are virtually devoid of encrusting or attached organisms due to the scarcity of drifting food particles in the deep ocean (Nybakken, 1993).

3.5.2.1.3.2 Distribution

Artificial shoreline structures (e.g., piers, wharfs, docks, pilings) in the Study Area occur at or along pierside locations (Section 2.1.10.1, Pierside Locations), including facilities associated with Navy ports and naval shipyards, and channels and routes to and from Navy ports.

The centroid points of mapped artificial structures in waters of the Study Area are depicted on Figure 3.5-5 through Figure 3.5-8. These include more than 15,000 mapped points, including mostly shipwrecks (over 11,000), oil/gas platforms (2,400), artificial reefs (1,400), and military towers (18) (Table 3.5-3). Artificial reefs may occur at individual permit sites or within large general permit areas. Very large individual permit areas and general permit areas range from nearly 100 to several hundred square miles; typical artificial reef permit areas range from less than 0.5 square mile to a few square miles (U.S. Department of the Navy, 2018a). Not shown on Figure 3.5-5 through Figure 3.5-8 are shipwrecks that are "address restricted" due to status on the National Register of Historic Places (e.g., Gen. C.B. Comstock located in Texas state waters) and ship hulks sunk during Naval sinking exercises.

Table 3.5-3: Number of Artificial Structures Documented in Large Marine Ecosystems and Open Ocean Areas of the AFTT Study Area

Large Marine Ecosystem and Open Ocean Areas	*Air Force Towers*	*Artificial Reef*	*Navy Towers*	*Oil/Gas Platform*	*Shipwreck*	*Grand Total*
Open Ocean	0	0	0	0	106	106
Caribbean Sea	0	9	0	0	350	359
Gulf of Mexico	6	1,166	0	2,400	6,174	9,746
Northeast U.S. Continental Shelf	0	62	4	0	3,845	3,911
Scotian Shelf	0	0	0	0	18	18
Southeast U.S. Continental Shelf	0	163	8	0	1,284	1,455
Grand Total	6	1,400	12	2,400	11,777	15,595

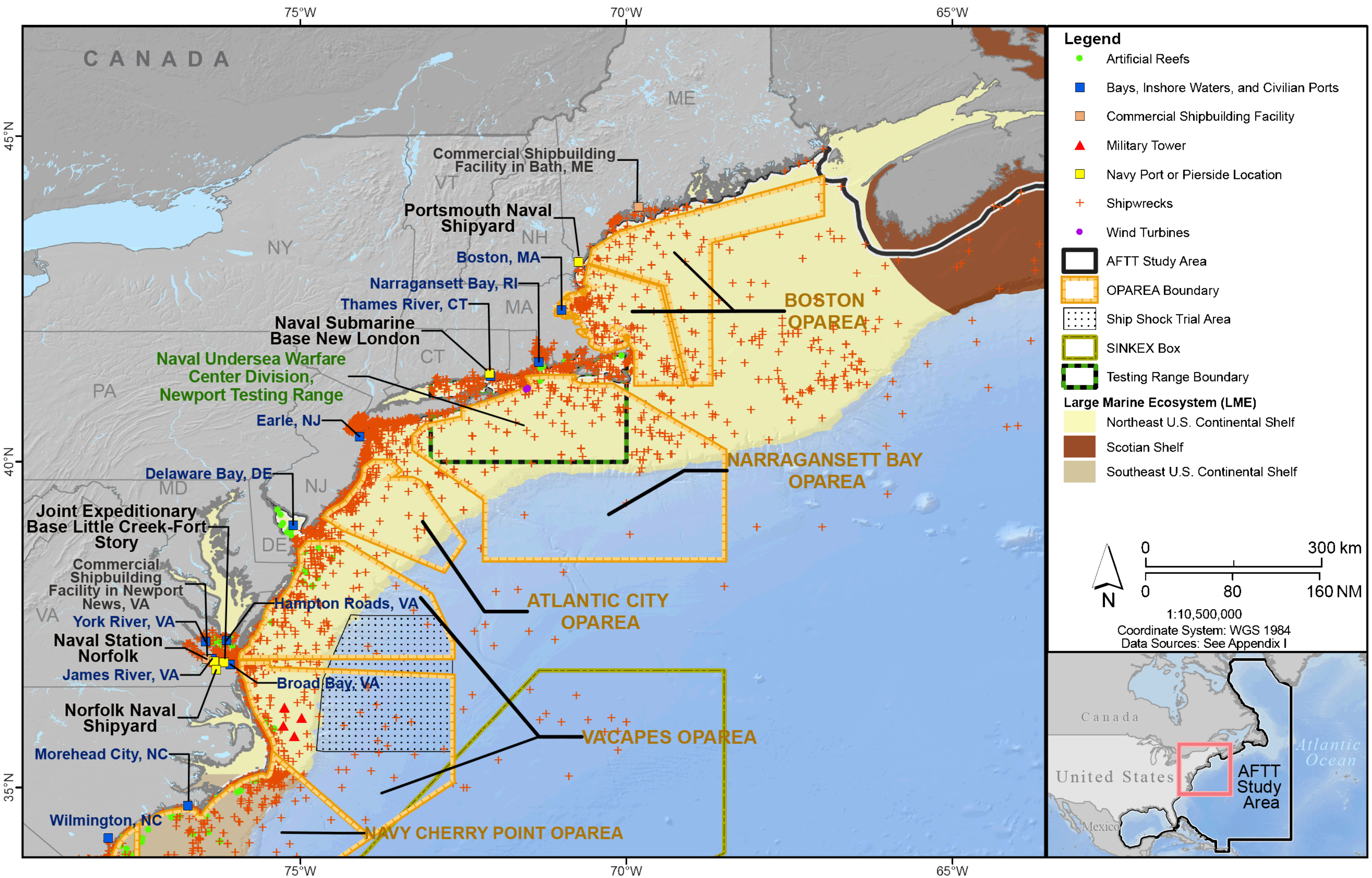
[1]There are no known, mapped artificial structures in the Gulf Stream, Labrador Current, Newfoundland-Labrador, North Atlantic Gyre, or West Greenland Shelf Large Marine Ecosystems.

3.5.2.1.4 General Threats

Estuarine and ocean environments worldwide are under pressure from a variety of human activities, such as coastal development, shoreline stabilization, dredging, flood control and water diversion; destructive fishing practices; offshore energy and resource development and extraction; and global climate change (Boehlert & Gill, 2010; Clark et al., 2016; Clarke et al., 2014; Crain et al., 2009; National Oceanic and Atmospheric Administration Marine Debris Program, 2016). These activities produce a range of physical and chemical stressors on habitats. Primary threats to marine habitats include habitat loss, degradation, or modification. Although stressors may be similar or wide-spread geographically, their effects on marine habitats are not random or equal. Human activities vary in their spatial distribution and intensity of impact (Halpern et al., 2008). Accordingly, their effects on habitats will vary depending on local differences in the duration, frequency, and intensity of stress; scale of effect; and environmental conditions. Areas where heavy concentrations of human activity co-occur with naval training and testing activities have the greatest potential for cumulative stress on the marine ecosystem (see Chapter 4, Cumulative Impacts, for more information).

3.5.2.1.4.1 Urbanization

Habitat loss and degradation are the primary threats of urbanization. Coastal development has resulted in loss of coastal dune and wetland habitats, modification of shorelines and estuaries, and degradation of water quality (Crain et al., 2009; Lotze et al., 2006). In addition, development has resulted in a proliferation of artificial structure habitats, such as breakwaters, jetties, rock groins, seawalls, oil and gas platforms, docks, piers, wharves, and underwater cables and pipelines, as well as artificial reefs.



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

Figure 3.5-5: Artificial Structures Within the Northeast U.S. Continental Shelf Large Marine Ecosystem and Open Ocean Areas

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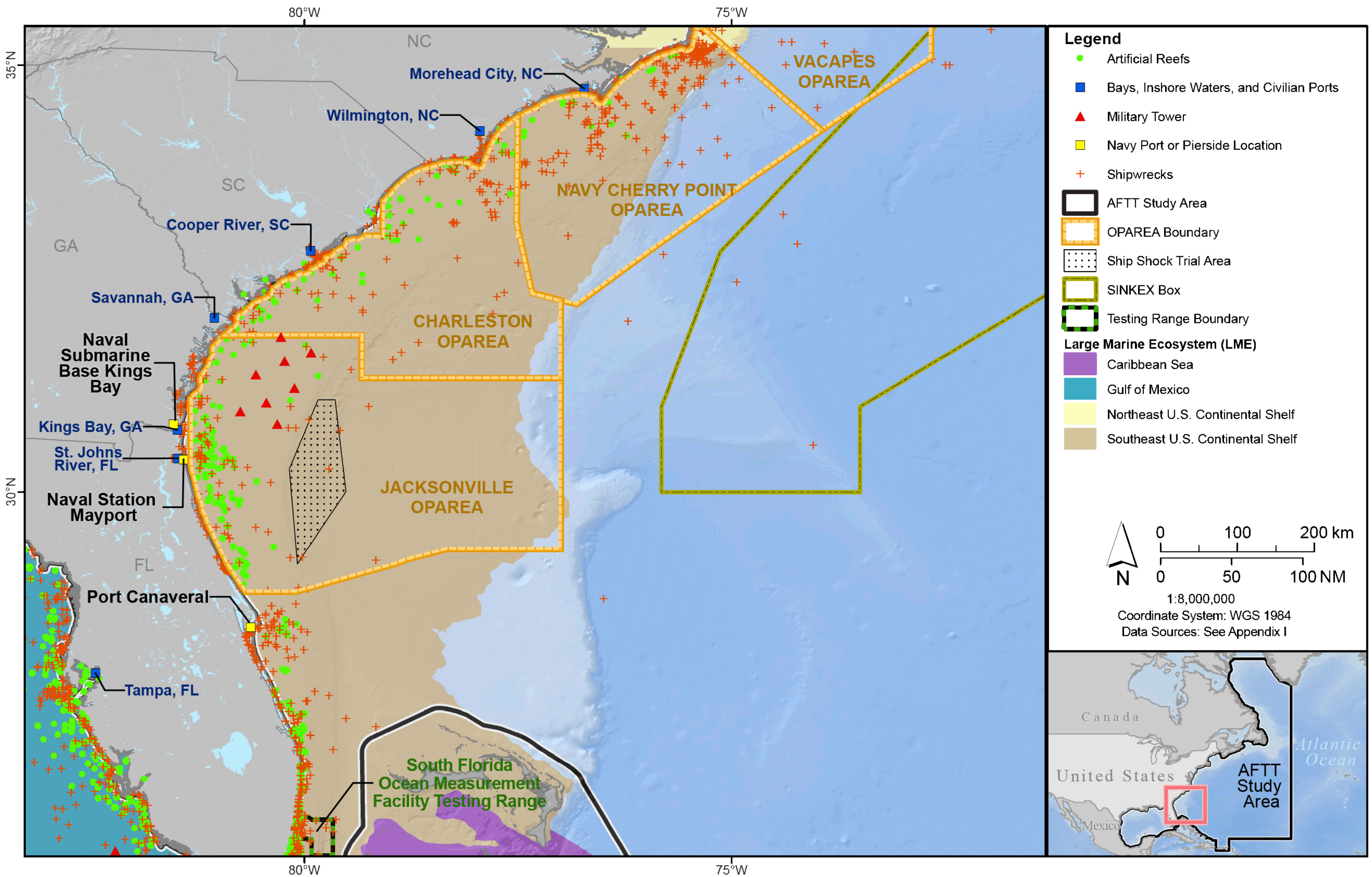

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.5-6: Artificial Structures Within the Southeast U.S. Continental Shelf Large Marine Ecosystem and Open Ocean Areas

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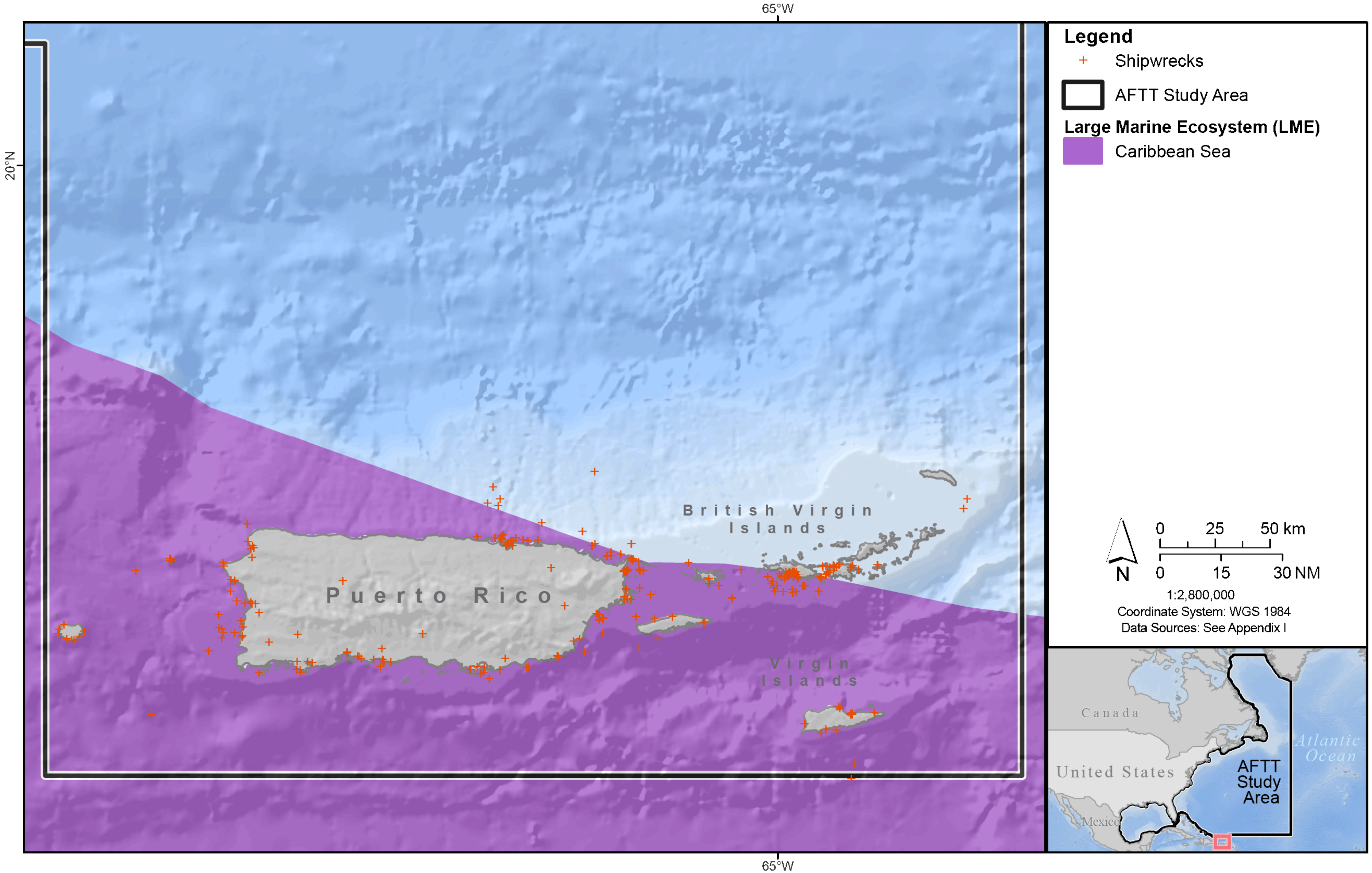

Notes: AFTT: Atlantic Fleet Training and Testing

Figure 3.5-7: Artificial Structures Within the Caribbean Sea Large Marine Ecosystem

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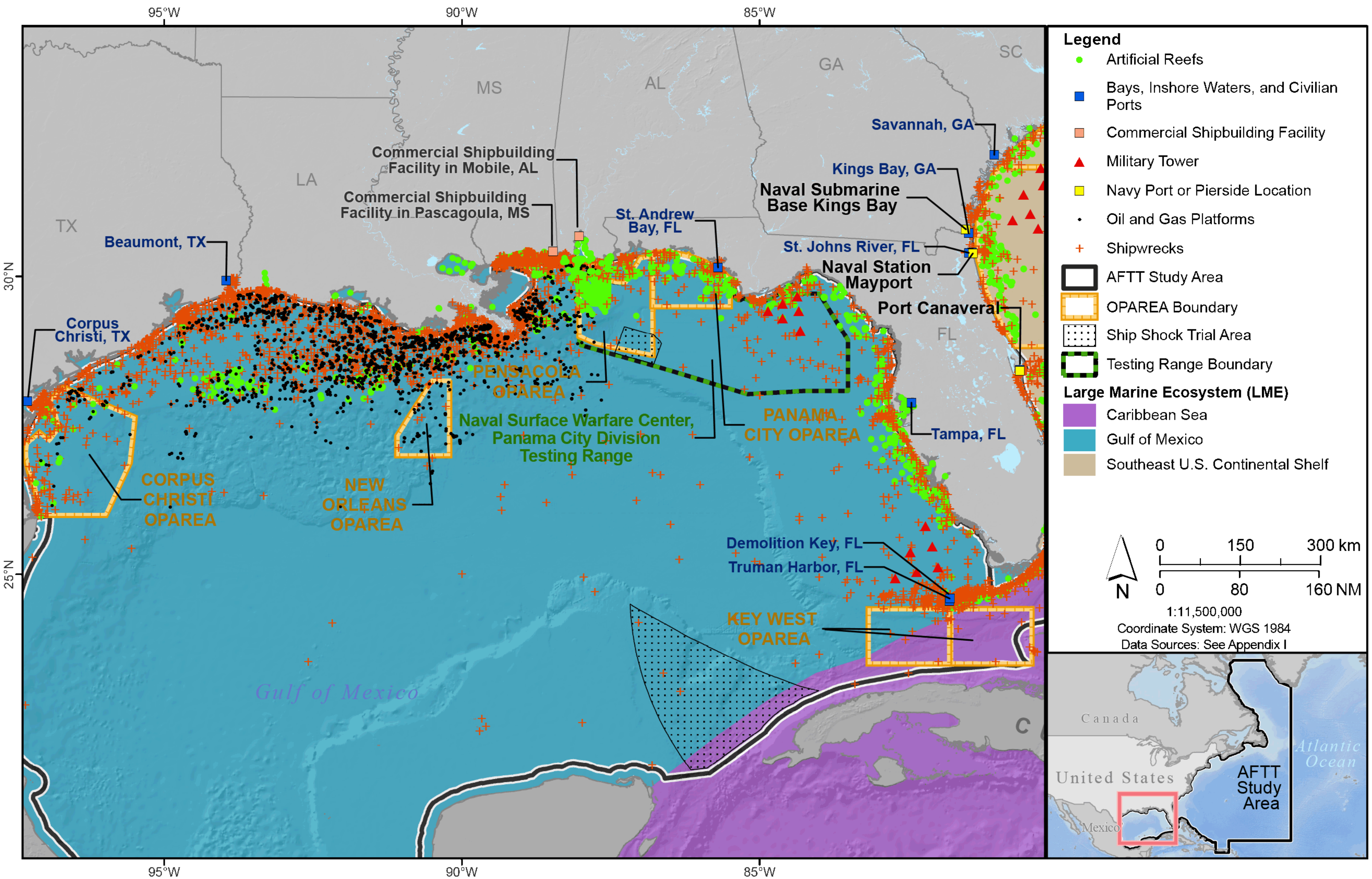

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area

Figure 3.5-8: Artificial Structures Within Western Portion of the Gulf of Mexico Large Marine Ecosystem

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Maintenance of coastal infrastructure, ports, and harbors disturbs or modifies intertidal and subtidal habitats, the extent of which varies depending on the type, scale, or frequency of the activity. For example, maintenance has increased the use of shoreline stabilization measures (engineered structures, beach nourishment) to reduce storm-related damages to coastal infrastructure. Flood control or shoreline stabilization measures may have temporary or long-term impacts on beach habitats and may also affect adjacent intertidal and subtidal habitats due to suspended sediment and sedimentation, altered sediment supply and transport dynamics, or creation of artificial substrates (Bacchiocchi & Airoldi, 2003). Periodic dredging and excavation of sediment is undertaken to maintain navigable channels, tidal exchange, and/or flood control capacity in bays and estuaries. Sediment removal directly disturbs subtidal soft bottom habitat and may indirectly disturb or modify adjacent habitats (Newell et al., 1998). A number of factors that may influence maintenance frequency include sediment characteristics, shoreline and watershed characteristics, oceanographic conditions, and climate.

Tourism is an important economic driver of development in coastal areas and represents an additional stressor in urbanized areas. For example, nearshore coral reefs in south Florida could be impacted by trampling; damage from divers and swimmers touching, kicking, breaking, sitting, or standing on coral; and improper boat anchoring. Within the highly urbanized portions of the Study Area such as in the northeast United States, human visitation and disturbances may impact rocky intertidal habitats (by trampling, overturning of rocks, collecting) and sandy beach habitats (by mechanical beach grooming).

3.5.2.1.4.2 Water Quality

Pollution of marine waters and the accumulation of contaminants in marine sediments pose threats to marine ecosystems, public health, and local economies of coastal regions (Crain et al., 2009). Marine and estuarine water and sediment quality may be influenced by industrial and wastewater discharges, soil erosion, stormwater runoff, vessel discharges, marine construction, and accidental spills. Activities that disturb or remove marine sediments also impact water quality and may alter physical and chemical properties of sediments at and adjacent to the disturbance due to sediment resuspension and sedimentation. Generally, threats to water and sediment quality are greater in waterbodies adjacent to watersheds with substantial urban or agriculture land uses. For more detailed discussion of water quality and potential impacts, see Section 3.2 (Sediments and Water Quality).

Large areas of bottom waters lacking dissolved oxygen, or “dead zones,” are documented in the Study Area off the Mississippi River outlet (Rabalais et al., 2002) and other large rivers flowing into coastal ocean waters (Diaz & Rosenberg, 2008). Whereas the physical structure of abiotic substrate is unaffected by dead zones, associated organisms are adversely impacted there. Refer to individual resource sections for specific stressors and impacts on living resources associated with marine substrates.

3.5.2.1.4.3 Commercial Industries

A variety of commercial development, operations, and activities impact marine habitats and associated organisms (e.g., oil/gas development, telecommunications infrastructure, steam and nuclear power plants, desalinization plants, alternative energy development, shipping and cruise vessels, commercial fishing, aquaculture, and tourism operations) (Crain et al., 2009). Commercial activities are conducted under permits and regulations that require companies to avoid and minimize impacts to marine habitats, especially sensitive hard bottom and biogenic habitats (e.g., coral reefs, shellfish beds, and vegetated habitats).

Marine habitats may be directly impacted during marine construction (e.g., cable laying and burial, dredging, pipeline installation, pile driving, work boat anchoring), commercial bottom fishing, and commercial vessel anchoring. Generally, disturbance impacts to soft bottom habitats are temporary; however, there is the potential to degrade the quality of soft bottom habitat for biological resources depending on the extent and frequency of disturbance (Newell et al., 1998). Hard bottom and biogenic habitats are most vulnerable to damage or degradation by commercial industry development and operations. For example, anchors, anchor chains, or cables may damage habitats and abrade and remove organisms from hard bottom surfaces. Commercial fishing use of dredges and bottom trawls impacts bottom topography and sediments and may degrade habitat quality and associated biological communities (Clark et al., 2016). Abandoned or lost fishing gear may alter the structure of abiotic habitats and result in abrasion or entanglement of organisms.

Indirect impacts to habitats may occur from commercial development, discharges, or accidental spills that degrade water or sediment quality. Threats associated with impacts to water and sediment quality are further described in Section 3.2 (Sediments and Water Quality, Affected Environment). Accidental spills have the potential to contaminate and degrade marine habitats by coating hard bottom or biogenic substrates as well as mixing into bottom sediments (Hanson et al., 2003). Many factors determine the degree of environmental damage from oil spills, including the type of oil, size and duration of the spill, geographic location, season, and types of habitats and resources present. Effects of oil on bottom habitats include potential long-term impacts on fish and wildlife populations.

3.5.2.1.4.4 Climate Change

All marine ecosystems are vulnerable to the widespread effects of climate change, which include increased ocean temperatures, sea level rise, ocean acidification, and changes in precipitation patterns (Hoegh-Guldberg & Bruno, 2010; Scavia et al., 2002). Rising ocean temperatures will cause waters to expand and ice caps to melt, driving sea levels to rise at various rates depending on geographic location and local environmental conditions. Sea level rise will have the greatest impacts on intertidal and coastal ecosystems that have narrow windows of tolerance to flooding frequency or depth (Crain et al., 2009). Changes in ocean temperatures also are projected to alter ocean circulation, upwelling, and nutrient distribution patterns. It is projected that wet tropical areas and mid-latitude land will experience more frequent and extreme precipitation, which will increase erosion-related sedimentation and runoff to coastal habitats (Keener et al., 2012). The climatic effects will be superimposed upon, and interact with, a wide array of current stresses, including excess nutrient loads, overfishing, invasive species, habitat destruction, and chemical contamination (Scavia et al., 2002).

3.5.2.1.4.5 Marine Debris

In the past decade, marine debris has been increasingly recognized as a key threat to marine ecosystems throughout the world. The Marine Debris Act (33 United States Code 1951 et seq.) defines marine debris as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment. Artificial substrate that provides hard bottom habitat for marine organisms is discussed in Section 3.4 (Invertebrates). This section focuses on the aspects of marine debris that pose a threat to marine habitats. The accumulation of marine debris can alter and degrade marine habitats through physical damage (e.g., abrasion, shearing); changes to the physical and chemical composition of sediments; and reductions in oxygen and underwater light levels (National Oceanic and Atmospheric Administration Marine Debris Program, 2016). Accumulation or concentration also can degrade the aesthetic appeal of coastal habitats for recreational use, decrease visitation and tourism, require costly cleanups, and impact local economies (Leggett et al., 2014). A multiyear study conducted from 1997–2007 along the southeast Atlantic coast concluded the vast majority of marine debris was either land based (38 percent), general source (42 percent), or ocean based (e.g., items originating from recreational and commercial fishing, shipping, and tourism activities) (20 percent) (Ribic et al., 2010); no items of military origin were differentiated.

3.5.3 Environmental Consequences

This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.3.3 (Identifying Stressors for Analysis) could impact marine habitats as defined in this section in the Study Area. Table 2.6-1 (Proposed Training Activities per Alternative) through Table 2.6-4 (Office of Naval Research Proposed Testing Activities per Alternative) present the proposed training and testing activities (including number of events and locations). General characteristics of all Navy stressors were introduced in Section 3.0.3.3 (Identifying Stressors for Analysis). The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors analyzed for habitats are:

- **Explosives** (explosives detonated on or near the bottom)
- **Physical Disturbance and Strikes** (vessels and in-water devices; military expended materials; seafloor devices; pile driving)

Impacts of explosives and military expended materials were assessed based on three types of analyses: (1) a conservative scenario assuming all the impacts occur on a single habitat type in an affected area (in a 1-year increment), (2) a more realistic situation in which the impacts are spread proportionally among the habitat types in an affected area (e.g., if hard bottom represents 10 percent of the total habitat within a particular testing or training area or range complex, then 10 percent of the total impact is assumed to occur on hard bottom), and (3) in an increment of 5 years. The most accurate projection would be somewhere between the conservative and proportional distribution because there are locations in which specific training or testing occurs most frequently within range complexes. However, the number of training and testing activities that occur in the frequently used areas is not limited to a specific percentage as part of the proposed action in this document. The remaining stressors (vessels and in-water devices, seafloor devices, and pile driving) were analyzed based on the number of annual events estimated to occur within each range complex. The analysis includes consideration of the mitigation that the Navy will implement to avoid potential impacts on habitats from explosives and physical disturbance and strike stressors.

3.5.3.1 Acoustic Stressors

Acoustic stressors are not applicable to habitats due to the lack of hearing capabilities of abiotic habitats and will not be analyzed in this section.

3.5.3.2 Explosive Stressors

Background

This section analyzes the potential impacts of in-water explosions on or near the bottom resulting from training and testing activities, because those are the only explosives that are expected to potentially impact abiotic substrate.

Most explosive detonations during training and testing involving the use of high-explosive munitions, including bombs, missiles, and projectile casings, would occur in the air or near the water's surface.

Explosives associated with torpedoes, explosive sonobuoys, and explosive mines would occur in the water column; demolition charges could occur near the surface, in the water column, or the ocean bottom. Most surface and water column detonations would occur in waters greater than 3 NM from shore in water depth greater than 100 feet (ft.) and would not be expected to impact the bottom, although mine warfare and demolition detonations could occur in shallow water, and typically in a few specific locations within the Study Area. This section only evaluates the impact of explosives placed on the bottom, because the physical structure of the water column is not affected by explosions. The potential impacts of in-water detonations on marine habitats are assessed according to size of charge (net explosive weight), charge radius, height above the bottom, substrate types in the area, and equations linking all these factors.

An explosive charge would produce percussive energy that would be absorbed and reflected by the bottom. Hard bottom would mostly reflect the energy (Berglind et al., 2009), whereas a crater would be formed in soft bottom (Gorodilov & Sukhotin, 1996). For a specific size of explosive charge, crater depths and widths would vary depending on depth of the charge and substrate type. There is a nonlinear relationship between crater size and depth of water, with relatively small crater sizes in the shallowest water, followed by a spike in size at some intermediate depth, and a decline to an average flat line (indicating similar crater size for all charge weights) at greater depth (Gorodilov & Sukhotin, 1996; O'Keeffe & Young, 1984). Radii of the craters reportedly vary little among unconsolidated substrate types (O'Keeffe & Young, 1984). On substrate types with non-adhesive particles (everything except clay), the effects should be temporary, whereas craters in clay may persist for years (O'Keeffe & Young, 1984). Soft substrate moves around with the tides and currents and depressions are only short-lived (days to weeks) unless they are maintained.

3.5.3.2.1 Impacts from Explosives

3.5.3.2.1.1 Impacts from Explosives Under Alternative 1

Impacts from Explosives Under Alternative 1 for Training Activities

Relevant training activities under Alternative 1 include explosives used during mine countermeasures, mine neutralization using remotely operated vehicles, and mine neutralization explosive ordnance disposal, among others (see Appendix A, Navy Activity Descriptions, for descriptions of these activities). The number and locations for explosives under Alternative 1 are provided in Section 3.0.3.3.4.2 (Military Expended Materials). The Navy testing and training areas listed by range complex, acreages of abiotic habitat by type, and percent usage on the bottom are shown in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

The analysis assumes that half the charges that could be detonated on the bottom during training activities are actually detonated on the bottom. This represents a conservative estimate, as in reality a much lower percentage of detonations is likely to occur directly on the seafloor. The determination of impact is based on estimated crater footprint sizes associated with the following net explosive weight explosions on the bottom: 0.5, 5, 10, 20, and 60 pounds. Note that mitigation measures that may prevent impacts are not included in the quantitative assessment (Chapter 5, Mitigation). Only the acreage in the large marine ecosystem areas was included in percentages shown in Table 3.5-2. The areas within the Atlantic Basin/abyssal zone were not included in order to focus on bottom areas likely to have a combination of suitable habitat, supply of sedentary invertebrate larvae, and sufficient food particles for filtration or deposit-feeding. Artificial substrate was not included, because it was inconsistently included for mapping and it likely represented a miniscule percentage of habitat types in the large marine ecosystems.

The mine neutralization and other training activities involving explosives could occur over a larger area, to support the added flexibility of conducting activities anywhere within the specified range complexes. Based on the number of charges and impact areas per year, the conservative scenarios for annual hard bottom impacts are 7.5, less than 0.5, less than 0.5, and 0.5 acres in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Caribbean and Gulf of Mexico, and Gulf of Mexico Large Marine Ecosystems, respectively (see Table F-22, Potential Impact from Explosives On or Near the Bottom for Training Activities Under Alternative 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). This represents less than 0.01 percent of the available hard bottom in each of the large marine ecosystems.

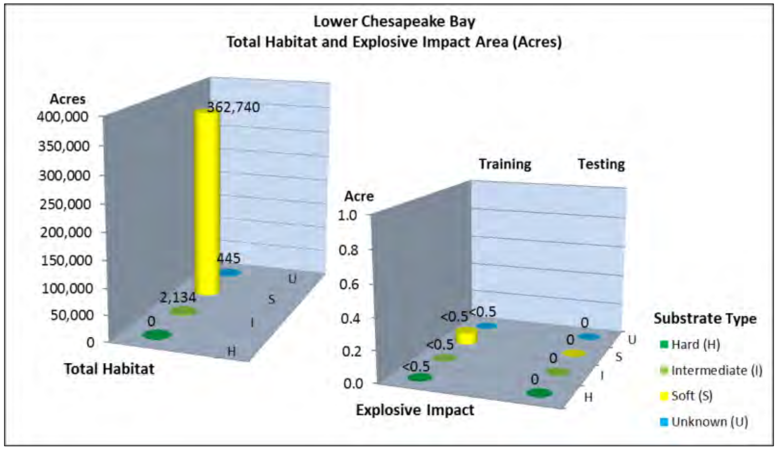
An analysis was conducted in order to determine the proportional impact of explosives training on marine habitats in each of the training areas within the Study Area (Figure 3.5-9). Based on the proportional analysis, total annual explosive impacts to hard substrate from explosives training activities would be less than 0.5 acre. Annual impacts to other substrate types would be approximately 0.5, 8.0, and less than 0.5 acres for intermediate, soft, and unknown substrates, respectively (Table F-31, Proportional Impact to Bottom Habitat from Training Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). See Appendix F (Military Expended Materials and Direct Strike Impact Analysis) for detailed analysis of explosive impacts from training activities in each Training Area. Table F-22 (Potential Impact from Explosives On or Near the Bottom for Training Activities Under Alternative 1 and 2 in a Single Year) provides potential annual impacts from explosives on or near the bottom for training activities under Alternatives 1 and 2.

An analysis was also conducted to evaluate impacts accumulating over the course of a 5-year period. The analysis assumed that all impacts would accumulate. In reality, some habitat would recover over time as soft substrates are dynamic systems and craters could refill. The total footprint for impacts from high explosives over a 5-year period, based on a conservative scenario, would be approximately 44.0 acres. Of this, less than 0.03 percent of the total area of intermediate and soft bottom and less than 0.01 percent of hard bottom would be anticipated. Details of this analysis can be found in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

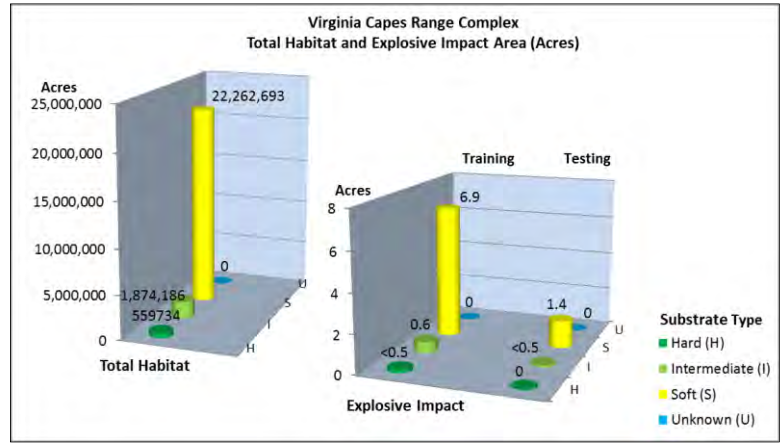
Under Alternative 1, the areas of bottom habitat in the AFTT Study Area affected annually or over a 5-year period by in-water detonations for training activities would be a negligible portion of available bottom habitat. Training events that include seafloor detonations would be infrequent, the percentage of the Study Area affected would be small, and the disturbed areas are likely soft bottom areas that recover relatively quickly from disturbance. Therefore, in-water explosions under Alternative 1 would mostly be limited to local and short-term impacts on habitat structure in the Study Area.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigations to avoid impacts from explosives on habitats in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks. Mitigation for seafloor resources was not included in the quantitative assessment of habitat impacts; however, it will help the Navy further avoid the potential for impacts on habitats from certain explosive activities.

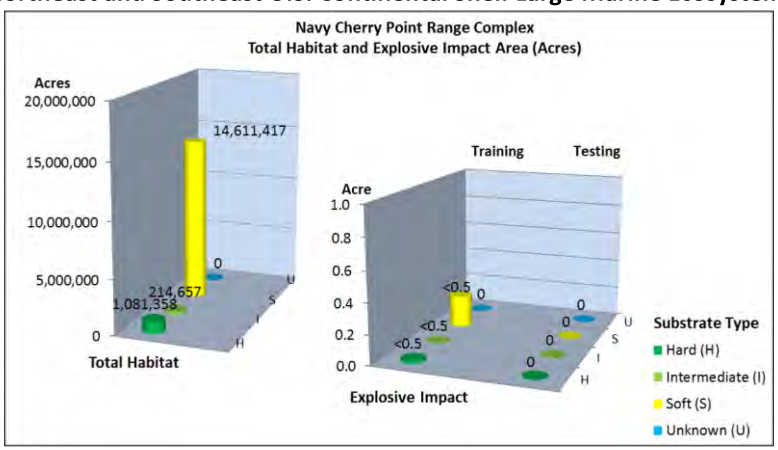
Northeast U.S. Continental Shelf Large Marine Ecosystem



Northeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone



Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems



Southeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone

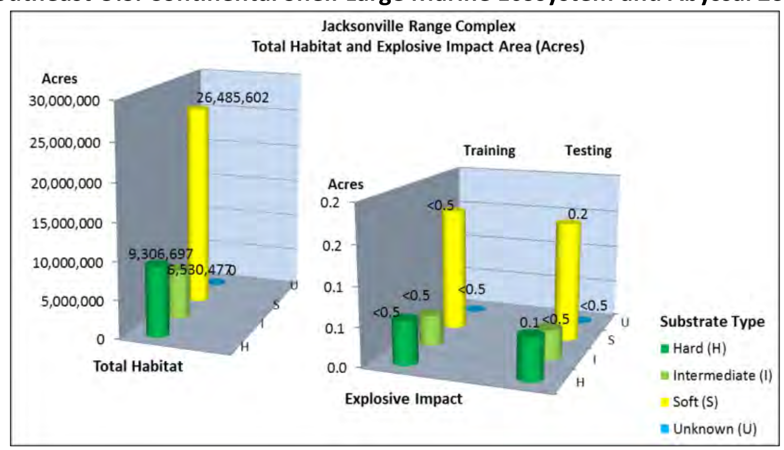
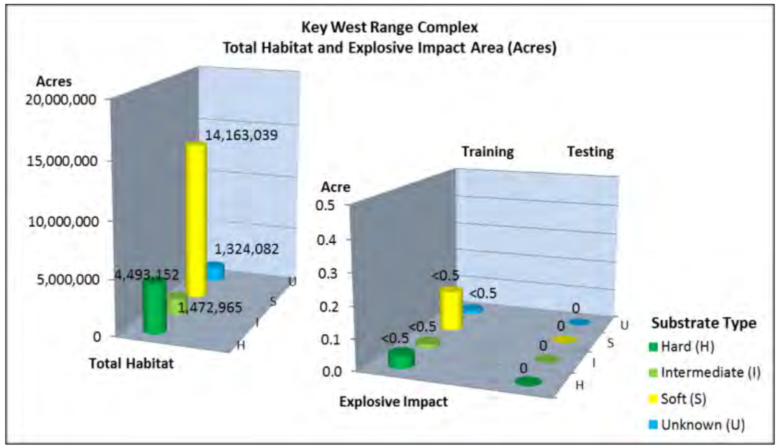
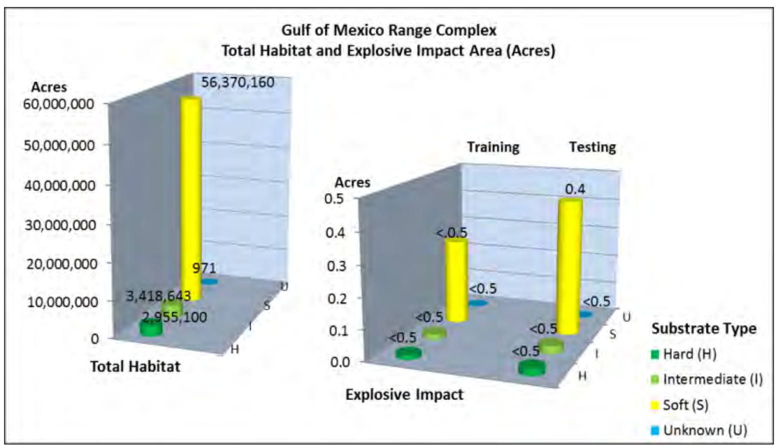


Figure 3.5-9: Alternative 1 – Annual Proportional Impact (Acres) from Explosives by Substrate Type for Training and Testing Compared to Total Vulnerable Habitat Within the Range Complexes of the Large Marine Ecosystems Within the Study Area

Caribbean and Gulf of Mexico Large Marine Ecosystems



Gulf of Mexico Large Marine Ecosystem



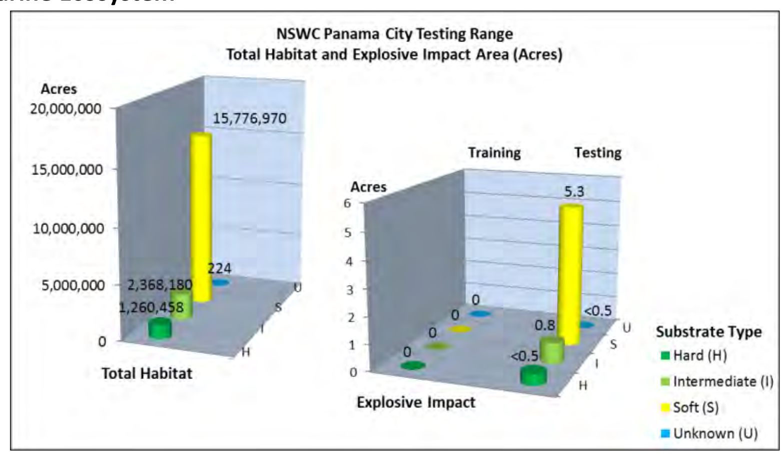


Figure 3.5-9: Alternative 1 – Annual Proportional Impact (Acres) from Explosives by Substrate Type for Training and Testing Compared to Total Vulnerable Habitat Within the Range Complexes of the Large Marine Ecosystems Within the Study Area (continued)

Impacts from Explosives Under Alternative 1 for Testing Activities

Relevant testing activities under Alternative 1 include, among others, explosives used in anti-submarine warfare, mine neutralization explosive ordnance disposal, and air-to-surface bombing tests (see Appendix A, Navy Activity Descriptions, for descriptions of these activities).The general locations for Alternative 1 activities are listed in Appendix A (Navy Activity Descriptions) and shown on Figure 3.5-1 through Figure 3.5-4.

Based on the number of charges and impact areas per year, the conservative scenarios for hard bottom area impacted are 1.5, less than 0.5, and 7.0 acres in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems, respectively (Table F-23, Potential Impact from Explosives On or Near the Bottom for Testing Activities Under Alternative 1 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). This represents less than 0.01 percent of hard bottom habitat for each of the large marine ecosystems.

Additional analysis was conducted in order to determine the proportional impact of explosives testing on marine habitats in each of the range complexes and testing ranges within the Study Area (Figure 3.5-9). Based on the proportional analysis of impacts, total explosive impacts to hard substrate from testing activities would be approximately 0.5 acre. Impacts to other substrate types would be approximately 1.0 and 7.5 acres for intermediate and soft substrates, respectively. Impacts to unknown substrate would be less than 0.5 acre (Table F-31, Proportional Impact to Bottom Habitat from Training Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). See Appendix F for detailed analysis of explosive impacts from testing activities in each range complex and testing range.

Analysis was also conducted to evaluate impacts accumulating over the course of a 5-year period. The analysis assumed that all impacts would be cumulative. In reality, some habitat would recover over time, as soft substrates are dynamic systems and craters could refill. Areas of hard bottom and other sensitive habitats could be avoided using the Protective Measures Assessment Protocol. The total footprint for impacts from high explosives over a 5-year period, based on a conservative scenario, would be approximately 43.5 acres. Of this, less than 0.01 percent of the total area of each habitat type (hard, intermediate, and soft) would be impacted. Details of this analysis can be found in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Under Alternative 1, the areas of bottom habitat in the AFTT Study Area affected annually by in-water detonations for testing activities would be a negligible portion of available bottom habitat (less than 0.01 percent for each substrate type). Testing events that include seafloor detonations would be infrequent, the percentage of testing area affected would be small, and the disturbed areas are likely soft bottom areas that recover relatively quickly from disturbance. Therefore, in-water explosions under Alternative 1 would mostly be limited to local and short-term impacts on habitat structure in the Study Area.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigations to avoid impacts from explosives on habitats in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks. Mitigation for seafloor resources was not included in the quantitative assessment of habitat impacts; however, it will help the Navy further avoid the potential for impacts on habitats from certain explosive activities.

3.5.3.2.1.2 Impacts from Explosives Under Alternative 2

Impacts from Explosives Under Alternative 2 for Training Activities

Relevant training activities under Alternative 2 include explosives used during anti-submarine warfare, mine neutralization explosive ordnance disposal, and air-to-surface bombing tests, among others (see Appendix A, Navy Activity Descriptions, for descriptions of these activities.) Explosive activities would be the same under Alternative 2 as those analyzed under Alternative 1, as only the frequency and duration of sonar activities would differ. The general locations for these activities under Alternative 2 are listed in Appendix A (Navy Activity Descriptions) and are shown on Figure 3.5-1 through Figure 3.5-4. The Navy testing and training areas, listed by large marine ecosystem and acreages of abiotic habitat by type, are shown in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Training events that include seafloor detonations would be infrequent, the percentage of testing area affected would be small, and the disturbed areas are likely soft bottom areas that recover relatively quickly from disturbance. Therefore, in-water explosions under Alternative 2 would mostly be limited to local and short-term impacts on habitat structure in the Study Area.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigations to avoid impacts from explosives on habitats in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks. Mitigation for seafloor resources was not included in the quantitative assessment of habitat impacts; however, it will help the Navy further avoid the potential for impacts on habitats from certain explosive activities.

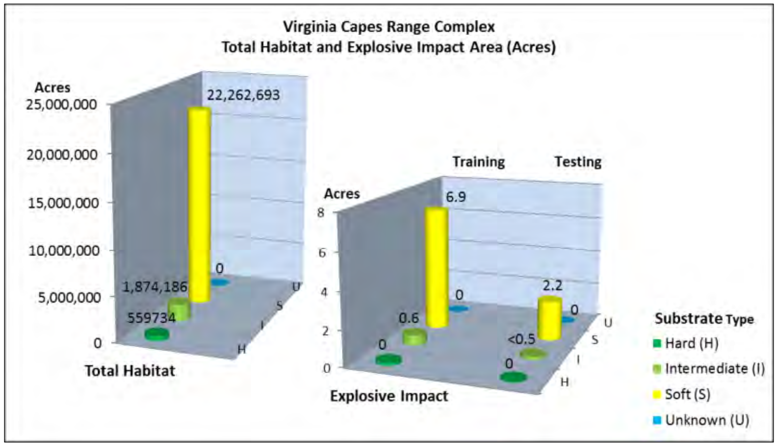
Impacts from Explosives Under Alternative 2 for Testing Activities

Relevant testing activities included in Alternative 2 that differ from Alternative 1 include Naval Air Systems Command's airborne mine neutralization system test and anti-submarine warfare tracking test–maritime patrol aircraft. Impacts from other activities would remain the same as discussed above under Alternative 1 impacts from explosives for testing. The general locations for Alternative 2 activities are listed in Appendix A (Navy Activity Descriptions) and shown on Figure 3.5-1 through Figure 3.5-4.

Based on the number of charges and impact areas per year, the conservative scenarios for hard bottom are 2.5, less than 0.5, and 9.0 acres in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems, respectively (Table F-24, Potential Impact from Explosives On or Near the Bottom for Testing Activities Under Alternative 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). This represents less than 0.01 percent of hard bottom, intermediate bottom, and soft bottom habitat in each area.

Analysis was conducted in order to determine the proportional impact of explosives testing on marine habitats in each of the training and testing areas within the Study Area. Only Virginia Capes and Naval Surface Warfare Center Panama City would differ in impacts from Alternative 1 (Figure 3.5-10). Based on the proportional analysis of impacts, total explosive impacts to hard substrate from testing activities would be approximately 0.5 acre. Impacts to other substrate types would be approximately 1.0 and 9.0 acres for intermediate and soft substrates, respectively. Impacts to unknown substrate would be less than 0.5 acre (Table F-31, Proportional Impact to Bottom Habitat from Training Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). See Appendix F for detailed analysis of explosive impacts from testing activities in each training area.

Northeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone



Gulf of Mexico Large Marine Ecosystem

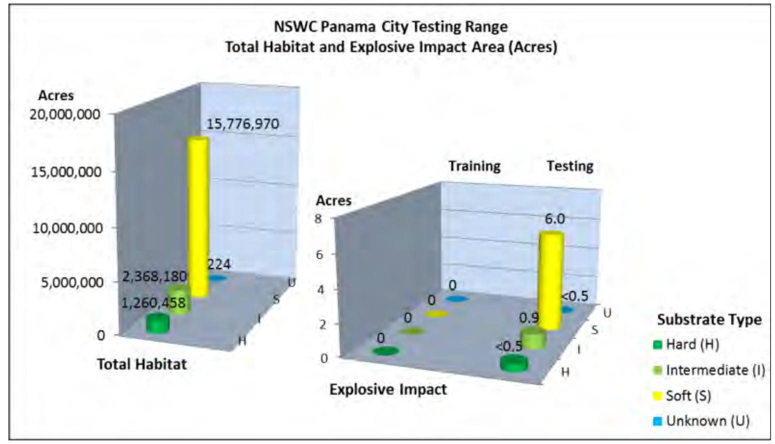


Figure 3.5-10: Alternative 2 – Annual Proportional Impact (Acres) from Explosives by Substrate Type for Training and Testing Compared to Total Vulnerable Habitat Within the Range Complexes of the Large Marine Ecosystems Within the Study Area

Analysis was also conducted to evaluate impacts accumulating over the course of a 5-year period. The analysis assumed that all impacts would accumulate. In reality, some habitat would recover over time, as soft substrates are dynamic systems and craters could refill. The total footprint for impacts from high explosives over a 5-year period, based on a conservative scenario, would be approximately 58.0 acres. However, proportional impacts would still affect less than 0.01 percent of the total area of each habitat type (hard, intermediate, and soft). Details of this analysis can be found in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Under Alternative 2, the areas of bottom habitat in in the large marine ecosystems affected annually by in-water detonations for testing activities would be a negligible portion of available bottom habitat (less than 0.01 percent annually). Testing events that include seafloor detonations would be infrequent and the percentage of testing area affected would be small, and the disturbed areas are likely soft bottom areas that recover relatively quickly from disturbance. Therefore, in-water explosions under Alternative 2 would mostly be limited to local and short-term impacts on marine habitat structure in the Study Area.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigations to avoid impacts from explosives on habitats in mitigation areas throughout the Study Area. For example, the Navy will not conduct explosive mine countermeasure and neutralization activities within a specified distance of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks. Mitigation for seafloor resources was not included in the quantitative assessment of habitat impacts; however, it will help the Navy further avoid the potential for impacts on habitats from certain explosive activities.

3.5.3.2.1.3 Impacts from Explosives Under the No Action Alternative

<u>Impacts from Explosives Under the No Action Alternative for Training and Testing Activities</u>

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

3.5.3.3 Energy Stressors

Energy stressors are not applicable to habitats, since activities that include the use of energy-producing devices are typically conducted at or above the surface of the water and would not impact bottom habitats. Therefore, they are not analyzed in this section.

3.5.3.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and strike stressors resulting from the Navy training and testing activities within the Study Area. This analysis includes the potential impacts of (1) vessels and in-water devices, (2) military expended materials (3) seafloor devices, and (4) pile driving.

Impacts from physical disturbances or strikes resulting from Navy training and testing activities on biota inhabiting soft bottom (habitat for seagrasses, clams, etc.) and hard bottom (habitat for hard corals, seaweed, sponges, etc.) substrates are discussed in Section 3.3 (Vegetation) and Section 3.4 (Invertebrates). Potential impacts to the underlying substrates (soft, intermediate, hard, or artificial) are analyzed here.

3.5.3.4.1 Impacts from Vessels and In-Water Devices

Vessels conducting training and testing activities in the Study Area include large ocean-going ships and submarines typically operating in waters deeper than 100 meters, but also occasionally transiting inshore waters from ports and through the operating areas. Training and testing activities also include smaller vessels operating in inshore waters, typically at higher speeds (greater than 10 knots). Vessels used for training and testing activities range in size from small boats (less than 40 ft.) to nuclear aircraft carriers (greater than 980 ft.). Table 3.0-17 (Representative Vessel Types, Lengths, and Speeds) lists representative types of vessels, including amphibious warfare vessels, used during training and testing activities. Towed mine warfare and unmanned devices are much smaller than other Navy vessels, but would also disturb the water column near the device. Some activities involve vessels towing in-water devices used in mine warfare activities. The towed devices attached to a vessel by cables are smaller than most vessels, and are not towed at high speeds. Some vessels, such as amphibious vehicles, would intentionally contact the seafloor in the surf zone.

Vessels, in-water devices, and towed in-water devices could either directly or indirectly impact any of the habitat types discussed in this section, including soft and intertidal shores, soft and hard bottoms, and artificial substrates. In addition, a vessel or device could disturb the water column enough to stir up bottom sediments, temporarily increasing the local turbidity. The shore and nearshore environment is typically very dynamic because of its constant exposure to wave action and cycles of erosion and deposition. Along high-energy shorelines like ocean beaches, these areas would be reworked by waves and tides shortly after the disturbance. Along low-energy shorelines in sheltered inshore waters, the force of vessel wakes can result in elevated erosion and resuspension of fine sediment (Zabawa & Ostrom, 1980). In deeper waters where the tide or wave action has little influence, sediments suspended into the water column would eventually settle. Sediment settlement rates are highly dependent on grain size. Disturbance of deeper bottom habitat by vessels or in-water devices is possible where the propeller wash interacts with the bottom. However, most vessels transiting in shallow, nearshore waters are confined to navigation channels where bottom disturbance only occurs with the largest vessels. An exception would be for training and testing activities that occur in shallow, nearshore environments. Turbidity caused by vessel operation in shallow water, propeller scarring, and vessel grounding could impact habitats in shallow-water areas. In addition, physical contact with hard bottom areas can cause structural damage to the substrate. However, direct impacts to the substrate are typically avoided because they could slow or damage the vessel or in-water device. These disturbances would not alter the overall nature of the sediments to a degree that would impair their function as habitat. The following alternatives analysis specifies where these impacts could occur in terms of number of events with vessel movement or in-water devices during training or testing activities in different habitat areas.

3.5.3.4.1.1 Impacts from Vessels and In-Water Devices Under Alternative 1

<u>**Impacts from Vessels and In-Water Devices Under Alternative 1 for Training Activities**</u>

As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), the majority of the training activities include vessels. These activities could be widely dispersed throughout the Study Area, but would be more concentrated near naval ports, piers, and ranges. Navy training vessel traffic would be concentrated in the Northeast U.S. Continental Shelf Large Marine Ecosystem near Naval Station Norfolk in Norfolk, Virginia, and in the Southeast U.S. Continental Shelf Large Marine Ecosystem near Naval Station Mayport in Jacksonville, Florida. Amphibious landings would be restricted to designated beaches. 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. However, large vessel movement may also occasionally occur in any of the large marine ecosystems, as well as the Gulf Stream Open Ocean Area—specifically within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico Range Complexes and anywhere in the Gulf of Mexico. Use of in-water devices is concentrated within the Virginia Capes, Jacksonville, and Navy Cherry Point Range Complexes.

Because of the nature of vessel operation and intentional avoidance of bottom strikes, most shore and bottom habitats would not be exposed to vessel strikes but could be exposed to vessel disturbance by propeller wash. Groundings would be accidental and are rare. Amphibious vehicles are an exception, but only designated beaches that are naturally resilient to disturbance would be used. Therefore, while vessels may affect shore and bottom habitats, adverse impacts are not likely.

Shallow water habitats within the Study Area would have a very small potential to be exposed to vessel strikes. Vessels would pose little risk to habitats in the open ocean although, in coastal waters, currents from large vessels may cause resuspension of sediment. Vessels travelling at high speeds would generally pose more of a risk; however, the majority of high-speed vessels use jet propulsion instead of propellers, which reduces the chance of impact from propeller strikes.

With the exception of amphibious operations, vessel disturbance and strikes affecting habitats would be extremely unlikely. Shallow-water vessels typically operate in defined boat lanes with sufficient depths to avoid propeller or hull strikes of bottom habitats. However, for some inshore training activities the training areas outside of navigation channels may not have sufficient depth to prevent contact with the bottom or resuspension of sediments.

The direct impact of vessels on bottom habitats is restricted to amphibious training beaches, whereas the indirect impact of propeller wash and wakes from vessels or in-water devices could impact shallow-water training areas and sheltered shoreline habitats. However, the bottom disturbance associated with propeller wash represents only a temporary resuspension of sediment in the shallowest portion of training areas. The effect of surface wakes is limited to high-speed training along relatively sheltered shorelines and is likely indistinguishable from the effect of other vessel wakes or storms in waters open to the public. Sheltered waters restricted to the public are typically harbors where no wake speeds are enforced.

There is very little likelihood of impacts to habitats due to in-water devices because the devices are not expected to contact the seafloor during training activities, operational procedures typically avoid shallow areas and intentionally avoid vessels or devices contacting the bottom, and exposures would be localized, temporary, and would cease with the conclusion of the activity.

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

As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), Navy vessel movements and in-water device usage for testing activities would be similar to those described previously under training activities.

Because of the nature of vessel and in-water device operation and intentional avoidance of bottom strikes, most habitat would not be exposed to vessel or in-water device direct strikes.

The impact of vessels and in-water devices on marine habitats would be inconsequential because the footprint of potential impact is extremely small relative to the overall availability of habitat, operational procedures typically avoid shallow areas and intentionally avoid vessels or devices contacting the bottom, and exposures would be localized, temporary, and would cease with the conclusion of the activity.

3.5.3.4.1.2 Impacts from Vessels and In-Water Devices Under Alternative 2

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

As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), Navy vessel movements and in-water device usage under Alternative 2 would be similar to those described previously under Alternative 1 training activities, although the overall number of vessel operations would be slightly increased due to more active hull-mounted sonar operations. Use of in-water devices would also be slightly increased under this alternative.

Because of the nature of vessel and in-water device operation and intentional avoidance of bottom strikes, most habitat would not be exposed to vessel or in-water device direct strikes. Amphibious landings are an exception, but these activities are conducted in designated areas that have been historically used for this type of activity and are generally devoid of any quality habitat.

The impact of vessels and in-water devices on marine habitats would be inconsequential because the footprint of potential impact is extremely small relative to the overall availability of habitat, operational procedures typically avoid shallow areas and intentionally avoid vessels or devices contacting the bottom, and exposures would be localized, temporary, and would cease with the conclusion of the activity.

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

As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), Navy vessel movements and in-water device usage for testing activities under Alternative 2 would be similar to those described previously under Alternative 2 training activities.

Because of the nature of vessel and in-water device operation and intentional avoidance of bottom strikes, most habitats would not be exposed to vessel or in-water device direct strikes. Amphibious landings are an exception; however, they are not included in testing activities.

The impact of vessels and in-water devices on marine habitats would be inconsequential because the footprint of potential impact is extremely small relative to the overall availability of habitat, operational procedures typically avoid shallow areas and intentionally avoid vessels or devices contacting the bottom, and exposures would be localized, temporary, and would cease with the conclusion of the activity.

3.5.3.4.1.3 Impacts from Vessels and In-Water Devices Under the No Action Alternative

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

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

3.5.3.4.2 Impacts from Aircraft and Aerial Targets

Impacts from aircraft and aerial targets are not applicable to habitats, because aircraft and aerial targets would not contact or otherwise affect shore or bottom habitats and are not analyzed further in this section.

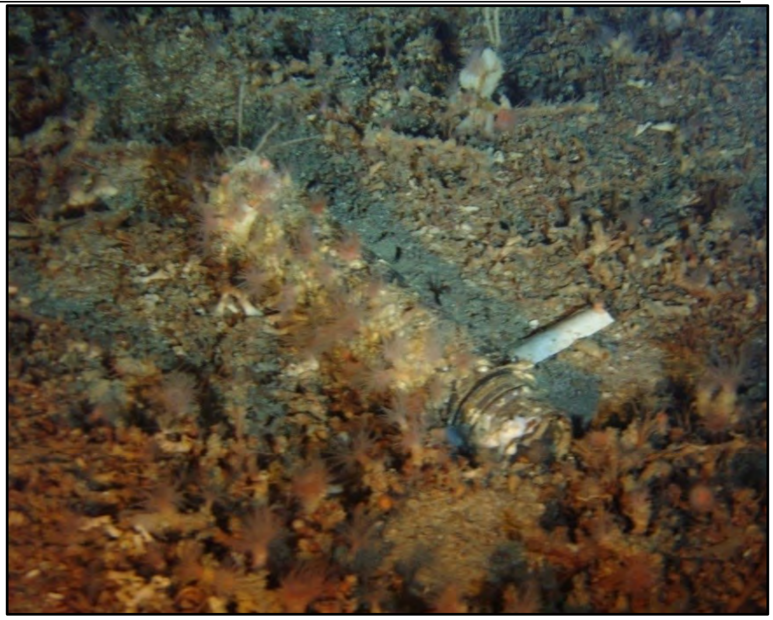
3.5.3.4.3 Impacts from Military Expended Materials

This section analyzes the potential for physical disturbance to marine substrates from the following categories of military expended materials: (1) non-explosive practice munitions, (2) fragments from high-explosive munitions, and (3) expended materials other than munitions, such as sonobuoys, expendable targets, and ship hulks. Note that expended materials do not include materials that are recovered or considered in-water or seafloor devices. Areas expected to have the greatest amount of expended materials are the Northeast U.S. Continental Shelf Large Marine Ecosystem, the Southeast U.S. Continental Shelf Large Marine Ecosystem, and the Gulf Stream Open Ocean Area (specifically within the Virginia Capes and Jacksonville Range Complexes). For a discussion of the types of activities that use military expended materials, see Appendix A (Navy Activity Descriptions) or Appendix B (Activity Stressor Matrices); for information on where they would be used and how much of each material is expended under each alternative, see Tables 3.0-24 (Number and Location of Non-Explosive Practice Munitions Expended During Training Activities) through 3.0-34 (Number and Location of Other Military Materials Expended During Testing Activities). Military expended materials have the potential to physically disturb marine substrates to the extent that they impair the substrate's ability to function as a habitat. These disturbances can result from several sources, including the impact of the expended material contacting the seafloor and moving around, the covering of the substrate by the expended material, or alteration of the substrate from one type to another.

The potential for military expended materials to physically impact marine substrates as they come into contact with the seafloor depends on several factors. These factors include, but are not limited to, the size, shape, type, density, and speed of the material through the water column; the amount of the material expended; the frequency of training or testing; water depth, water currents, or other disturbances; and the type of substrate. Most of the kinetic energy of the expended material, however, is dissipated within the first few feet of the object entering the water, causing it to slow considerably by the time it reaches the substrate. Because the damage caused by a strike is proportional to the force of the strike, slower speeds result in lesser impacts. Due to the water depth at which most training and testing events take place, a direct strike on either hard bottom or artificial structures (e.g., artificial reefs and shipwrecks) is unlikely to occur with sufficient force to damage the substrate. In softer substrates (e.g., sand, mud, silt, clay, and composites), the impact of the expended material coming into contact with the seafloor, if large enough and striking with sufficient momentum, may result in a depression and a localized redistribution of sediments as they are temporarily suspended in the water column. There may also be redistribution of unconsolidated sediment in areas with sufficient flow to move the sediment, creating a pattern of scouring on one side of the material and deposition on the other.

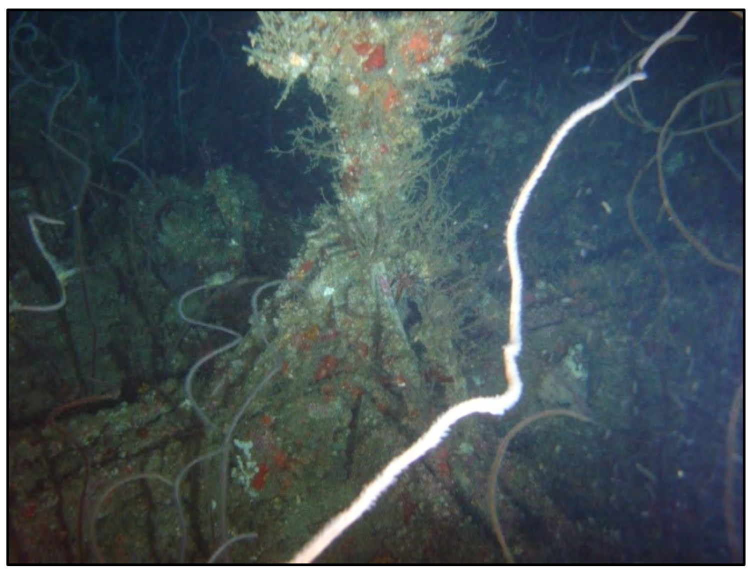
During Navy training and testing, countermeasures such as flares and chaff are introduced into marine habitats. These types of military expended materials are not expected to impact marine habitats as strike stressors, given their smaller size and low velocity when deployed compared to projectiles, bombs, and missiles.

Another potential physical disturbance that military expended materials could have on marine substrates would be to cover them or to alter the type of substrate and, therefore, its function as habitat. The majority of military expended materials that settle on hard bottom or artificial substrates, while covering the seafloor, may serve a similar habitat function as the substrate it is covering by providing a hard surface on which organisms can attach (Figure 3.5-11 and Figure 3.5-12). Similarity in attached organisms over the long term depends on similarity in structural features (Perkol-Finkel et al., 2006; Ross et al., 2016), fine surface texture, and mineral content (Davis, 2009). Natural hard bottom and artificial structures of a similar shape will eventually have similar communities of attached organisms if they have similar fine texture and mineral content. However, the smooth surface texture of intact military expended materials and lack of mineral content suggest a difference in species composition and associated functions. An exception would be expended materials, like the decelerators/parachutes utilized to deploy sonobuoys, lightweight torpedoes, expendable mobile anti-submarine warfare training targets, and other devices from aircraft, which would not provide a hard surface for colonization. In these cases, the hard bottom or artificial substrate covered by the expended material would not be physically damaged, but would have an impaired ability to function as a habitat for colonizing or encrusting organisms. There is potential for these items to drift over shallow-water or deep-sea coral habitats.



Note: Observed at approximately 350 meters in depth and 60 nautical miles east of Jacksonville, Florida. Of note is the use of the smoke float as a colonizing substrate for a cluster of sea anemones (U.S. Department of the Navy, 2010).

Figure 3.5-11: A Marine Marker Observed in an Area Dominated by Coral Rubble on the Continental Slope

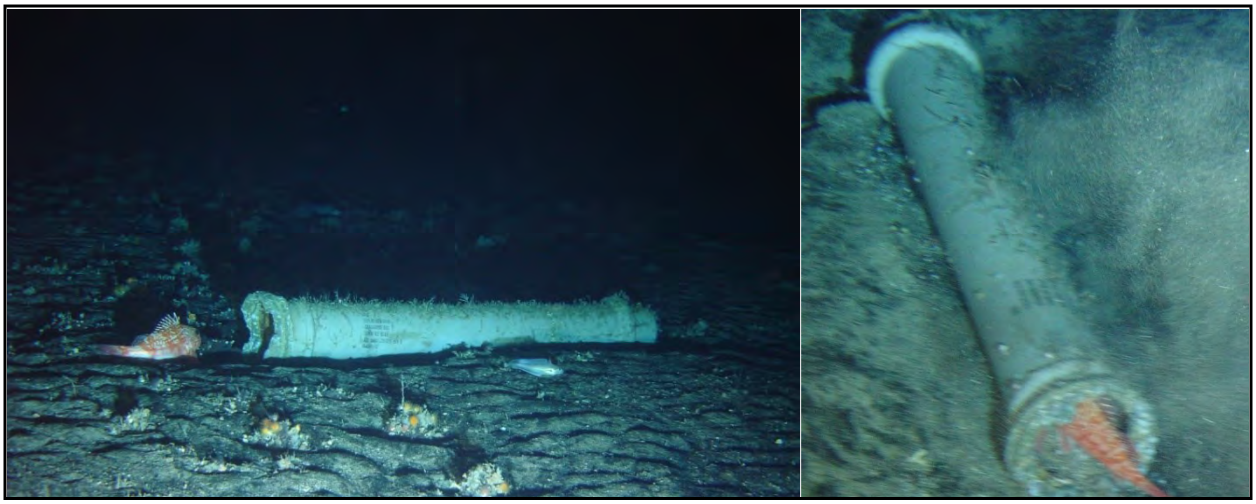


Note: Observed on the ridge system that runs parallel to the shelf break at approximately 80 meters in depth and 55 nautical miles east of Jacksonville, Florida. Of note is that encrusting organisms and benthic invertebrates readily colonize the artificial structure to a similar degree as the surrounding rock outcrop (U.S. Department of the Navy, 2010).

Figure 3.5-12: An Unidentified, Non-Military Structure on Hard bottom

Most military expended materials that settle on soft bottom habitats, while not damaging the actual substrate, would inhibit the substrate's ability to function as a soft bottom habitat by covering it with a hard surface. This would effectively alter the substrate from a soft surface to a hard structure and, therefore, would alter the habitat to be more suitable for organisms more commonly found associated with hard bottom environments

(U.S. Department of the Navy, 2010, 2011). Expended materials that settle in the shallower, more dynamic environments of the continental shelf would likely be eventually covered over by sediments due to currents and other coastal processes, or encrusted by organisms. Depending on the substrate properties and the hydrodynamic characteristics of the area, military expended materials may become buried rather quickly while in other areas they may persist on the surface of the seafloor for a more extended time. The offshore portion of the continental shelf experiences more sediment redistribution from oceanic currents (e.g., Gulf Stream) than distant surface waves. The effect of oceanic currents on sediment redistribution diminishes seaward of the continental shelf break: sediment along the continental slope and the Atlantic Basin/abyssal zone experience very little reworking from surface currents and waves. In the deeper waters of the continental slope and beyond where currents do not play as large of a role, expended materials may remain exposed on the surface of the substrate with minimal change for extended periods (Figure 3.5-13).

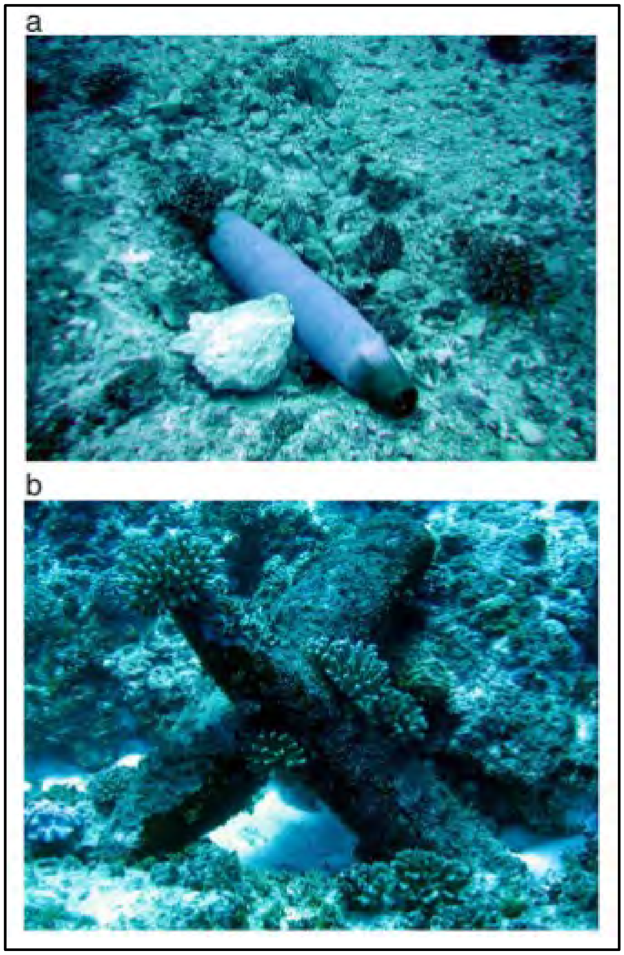


Note: The casing was observed in a sandy area on the continental slope approximately 425 meters in depth and 70 nautical miles east of Jacksonville, Florida. The casing has not become covered by sediments or encrusting organisms due to the depth and the relatively calm, current-free environment.

Figure 3.5-13: A 76-millimeter Cartridge Casing on Soft Bottom and a Blackbelly Rosefish (*Helicolenus dactylopterus*) Using the Casing for Protection When Disturbed

Whereas the impacts will accumulate somewhat through successive years of training and testing, some portion of the expended material will sink below the surface of shifting soft bottom habitat or become incorporated into natural hard bottom before crumbling into inorganic particulates. This will be the fate of military expended material whose density is greater than or equal to that of the underlying substrate (e.g., metal, cement, sand) (Traykovksi & Austin, 2017). Constituents of military expended material that are less dense than the underlying substrate (e.g., fabric, plastic) will likely remain on the surface substrate after sinking. In this case, the impact on substrate as a habitat is likely temporary and minor due to the mobility of such materials (refer to living resources sections for more information on the entanglement and ingestion risk posed by plastic and fabric constituents of military expended material). The impact of dense expendable materials on bottom substrate is prolonged in the large marine ecosystem areas that are seaward of the continental shelf. Between initial settlement and burial or complete degradation, these relatively stable objects will likely function as small artificial habitats for encrusting algae, attached macroalgae/seaweed, and/or sedentary invertebrates as well as small motile organisms (Figure 3.5-14).

Disturbance of the bottom from ship hulks may occur, but impairment of habitat function is not expected because the material is sunk in the abyssal zone where bottom organisms are generally small and sparsely populated (Nybakken, 1993); the deep ocean has a sparse supply of food items for sedentary deposit or filter feeders. The only densely populated areas in the deep ocean are around the occasional hydrothermal vent/cold seep.



a. MK 82 inert bomb (168 centimeters long) that directly impacted the seafloor at a depth of 12 meters on September 5 or 6, 2007; photographed on September 13, 2007. Area of destruction/ disturbance was approximately 17 square meters.

b. MK 82 bombs with Pocilloporid corals, algae, etc.

Source: (Smith & Marx, 2016)

Figure 3.5-14: Military Expended Material Functioning as Habitat

To determine the potential level of disturbance that military expended materials have on soft, intermediate, and hard bottom substrates, an analysis to determine the impact footprint was conducted for each range complex for each alternative. Three main assumptions were made that result in the impact footprints calculated being generally considered overestimates. First, within each category of expended items (e.g., bombs, missiles, rockets, large-caliber projectiles, etc.), the size of the largest item that would be expended was used to represent the sizes of all items in the category. For example, the impact footprints of missiles used during training exercises range from 1.5 to 40 square feet. For the analyses, all missiles were assumed to be equivalent to the largest in size, or 40 square feet. Second, it was also assumed that the impact of the expended material on the seafloor was twice the size of its actual footprint. This assumption accounts for any displacement of sediments at the time of impact as well as any subsequent movement of the item on the seafloor due to currents or other forces. This should more accurately reflect the potential disturbance to soft bottom habitats but would overestimate disturbance to hard bottom habitats since no displacement of the substrate would occur. Third, items with casings (e.g., small-, medium-, and large-caliber munitions; flares; sonobuoys; etc.) have their impact footprints doubled to account for both the item and its casing. Items and their casings were assumed to be the same size, even though depending on the munitions, one of them is often smaller than the other.

Once the impact footprints were calculated, three analyses were performed for each range complex: (1) a conservative scenario in which potential impact to each habitat type (soft, intermediate, and hard bottom habitats) in that range complex if all expended materials settled in areas with that substrate type, (2) a proportional analysis in which potential impact to each habitat type expended materials settled proportionally across all habitat types in the area, and (3) a 5-year scenario in which potential impact to the bottom habitats in that range complex over a 5-year period if activities continued at anticipated levels and impact accumulated over that period. During the analyses, the same dimensions were used for high-explosive munitions as were used for non-explosive practice munitions. The total area of the seafloor covered by the expended materials should be similar regardless of whether the item is intact or fragmented, despite the fact that high-explosive munitions will explode in the air, at the surface, or in the water column and only fragments would make it to the substrate.

Only the acreage in the large marine ecosystem areas was included in percentages. The areas within the Atlantic Basin and abyssal zone were not included in order to focus on bottom areas likely to have a combination of suitable habitat, supply of sedentary invertebrate larvae, and sufficient food particles for filtration or deposit-feeding. Artificial substrate was not included, because it was inconsistently included for mapping and it likely represented a miniscule percentage of habitat types in the large marine ecosystems.

According to surveys conducted at Farallon De Medinilla (a Department of Defense bombing range in the Mariana Archipelago) between 1997 and 2012, there was no evidence that the condition of the living resources assessed had changed or been adversely impacted to a significant degree by the training activities being conducted there. It should also be noted that the intended munition target was on the nearby land area, and water impacts were due to inaccuracy. The health, abundance, and biomass of fishes, corals, and other marine resources are comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago (Smith & Marx, 2016). However, the study noted that the decline in some important reef fish during their latest surveys was likely due to increasing attention from fishermen. Also, this is expected to be an extreme case based on the proximity to shallow-water coral reefs and the severe wave impact and associated movement of military expended materials due to the shallow margins of the islands where wave impact is most severe. Impacts to habitat from military expended material in the Study Area would be expected to be less severe. See Appendix F (Military Expended Materials and Direct Strike Impact Analysis) for detailed analyses of the impacts associated with military expended materials from Navy training and testing activities.

3.5.3.4.3.1 Impacts from Military Expended Materials Under Alternative 1

<u>Impacts from Military Expended Materials Under Alternative 1 for Training Activities</u>

Training activities involving military expended materials (Appendix A, Navy Activity Descriptions) would have the potential to impact the marine substrates within the areas in which the training is occurring. Each range complex was evaluated to determine what level of impact could be expected under Alternative 1.

To determine the percentage of a given substrate within a range complex that may potentially be impacted by military expended materials under a worst case scenario for each of the alternatives, the total impacted area for each range complex was divided by the total amount of that particular substrate type within the same range complex as provided in Table 3.5-2 (see also Appendix F, Military Expended Materials and Direct Strike Impact Analysis).

Military expended materials associated with training exercises under a conservative scenario would not impact more than 0.01 percent of the available soft bottom habitat annually within any of the training areas or range complexes. Likewise, the potential impact of the conservative scenario on intermediate bottom habitats within each range complex does not exceed 0.02 percent of the total available intermediate bottom. Impacts to hard substrate would not exceed 0.01 percent for any of the areas (see Table F-27, Potential Impact of Military Expended Materials from Training Activities on Each Substrate Type in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). Given that the probability of these conservative scenarios occurring is highly unlikely, the actual impact of military expended materials within each range complex under the Alternative 1 on hard bottom, intermediate bottom, or soft bottom substrates will be even less.

Decelerators/parachutes may be considered the most problematic impact on live hard bottoms in the Study Area due to the potential for such slowly sinking items to drift over shallow-water or deep-sea coral habitats. A decelerator/parachute settling on hard substrate would constitute a conversion to a softer substrate that could persist for a long time depending on the parachute material.

Additional analysis was conducted in order to determine the proportional impact of military expended material from training activities on marine habitats in each of the training areas within the Study Area (Figure 3.5-15). Based on the proportional analysis of impacts, total military expended materials impacts from training activities to vulnerable hard substrate would be approximately 11.5 acres. Impacts to other substrate types would be approximately 10.5, 84.5, and 1.5 acres for intermediate, soft, and unknown substrates, respectively (Table F-31, Proportional Impact to Bottom Habitat from Training Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). See Appendix F, for detailed analysis of military expended materials impacts from training activities in each range complex and other training locations.

An analysis was also conducted to evaluate impacts accumulating over the course of a 5-year period. The analysis assumed that all impacts would accumulate. In reality, soft bottom habitats may recover in the short term where heavier military expended materials are buried under shifting sediments; hard bottom habitats would recover over the long term where hard, stable military expended materials become overgrown with similar organisms. The total proportional impact footprint for impacts from military expended materials over a 5-year period would be approximately 58.0, 52.5, and 422.0 acres for hard bottom, intermediate bottom, and soft bottom, respectively. Approximately 7.5 acres of unknown habitat would be impacted. However, total impacts would still affect less than 0.04 percent of the total area of each habitat type (hard, intermediate, and soft) would be impacted. Details of this analysis can be found in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Military expended materials, including small caliber projectile casings, marine markers, flares, and flare parts, would also be utilized in inshore waterways. In the northeast, military expended materials would be expended in Narragansett Bay, Rhode Island; Lower Chesapeake Bay, James River and Tributaries, and York River. In the southeast, military expended material is employed in Cooper River, South Carolina; and Port Canaveral, Florida. Impacts from training activities under Alternative 1 in inshore waterways are very small, totaling only about 2.5 acres combined in the northeast inshore waterways and less than 0.5 acre in the southeast inshore waterways in the conservative scenario. Proportionally, in range complexes in the northeast, less than 0.5, 0.5, 2.0, and less than 0.5 acres of hard, intermediate, soft, and unknown substrate would be impacted, respectively (Figure 3.5-15). In the southeast, less than 0.5 acre of hard, intermediate, soft, or unknown substrate would be impacted (Figure 3.5-15).

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from military expended materials on habitats in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities within a specified distance of shallow-water coral reefs. Mitigation for seafloor resources was not included in the quantitative assessment of habitat impacts; however, it will help the Navy further avoid the potential for impacts on habitats from certain activities that involve the use of military expended materials.

Impacts from Military Expended Materials Under Alternative 1 for Testing Activities

Testing activities involving military expended materials (Appendix A, Navy Activity Descriptions) would have the potential to impact the marine substrates within the areas the testing is occurring. Each range complex and testing range was evaluated to determine what level of impact could be expected under Alternative 1.

To determine the percentage of the total soft bottom or hard bottom substrate within the Study Area that may potentially be impacted by military expended materials under a conservative scenario for each of the alternatives, the total impacted area for each testing range was divided by the total amount of that particular substrate type within the same testing range as provided in Table 3.5-2 (see also Appendix F, Military Expended Materials and Direct Strike Impact Analysis).

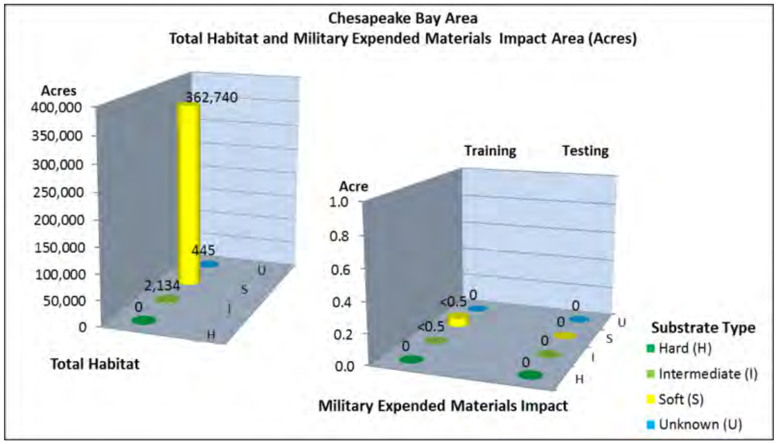
Military expended materials associated with testing activities under a conservative scenario would not impact more than 0.01 percent of the available soft bottom habitat annually within any of the testing areas. The potential impact of the conservative scenario on intermediate bottom habitats within each testing range does not exceed 0.02 percent of the total available intermediate bottom. Hard bottom impacts would not exceed 0.01 percent for any of the areas. Given that the probability of these worst case scenarios occurring is highly unlikely, the actual impact of military expended materials within each range complex under Alternative 1 on hard bottom, intermediate bottom, or soft bottom substrates will be even less.

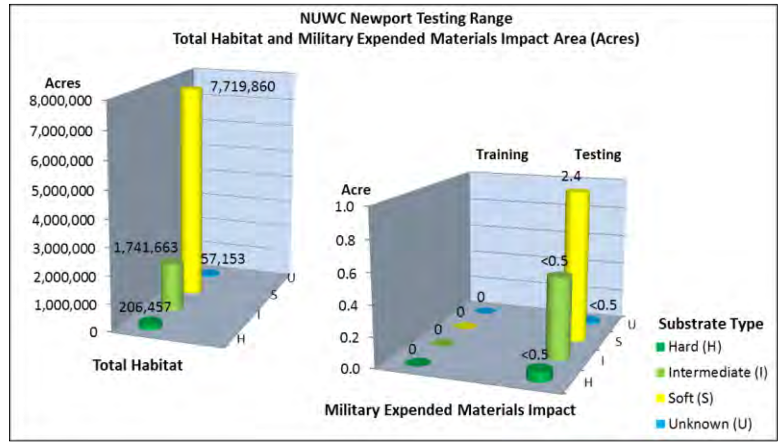
Decelerators/parachutes may be considered the most problematic impact on live hard bottoms in the Study Area due to the potential for such slowly sinking items to drift over shallow-water or deep-sea coral habitats. A decelerator/parachute settling on hard substrate would constitute a conversion to a softer substrate that could persist for a long time depending on the parachute material.

Additional analysis was conducted in order to determine the proportional impact of military expended material from testing activities on marine habitats in each of the range complexes and testing areas within the Study Area (Figure 3.5-15). Based on the proportional analysis of impacts, total military expended materials impacts to hard substrate from testing activities would be approximately 5.0 acres. Impacts to other substrate types would be approximately 5.0 and 42.0 acres for intermediate and soft substrates, respectively. Approximately 0.5 acre of unknown substrate would be impacted (Table F-32, Proportional Impact to Bottom Habitat from Testing Activities Under Alternatives 1 and 2 in a Single Year, in Appendix F, Military Expended Materials and Direct Strike Impact Analysis). See Appendix F for detailed analysis of military expended materials impacts from testing activities in each range complex or other testing area.

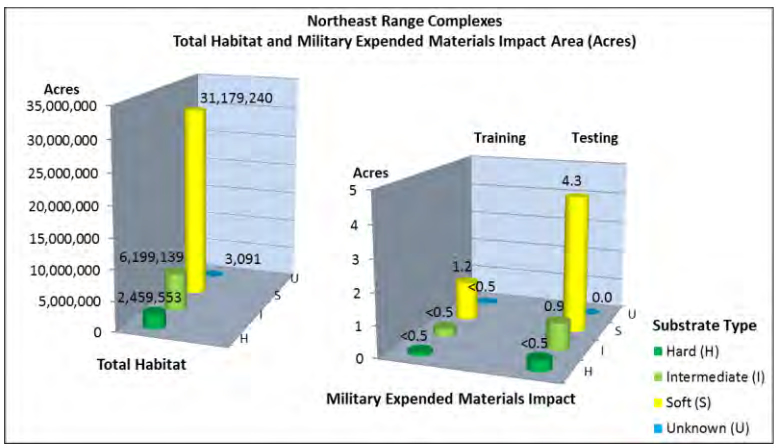
An analysis was also conducted to evaluate impacts accumulating over the course of a 5-year period. The analysis assumed that all impacts would accumulate. In reality, some habitat would recover over time, as soft substrates are dynamic systems and craters could refill. The total proportional impact footprint for impacts from high explosives over a 5-year period would be approximately 24.0, 25, and 204.5 acres for hard bottom, intermediate bottom, and soft bottom respectively. Approximately 1.5 acres of unknown habitat would be impacted. However, total impacts would still affect less than 0.05 percent of the total area of each habitat type (hard, intermediate, and soft) would be impacted. Details of this analysis can be found in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Northeast U.S. Continental Shelf Large Marine Ecosystem





Northeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone



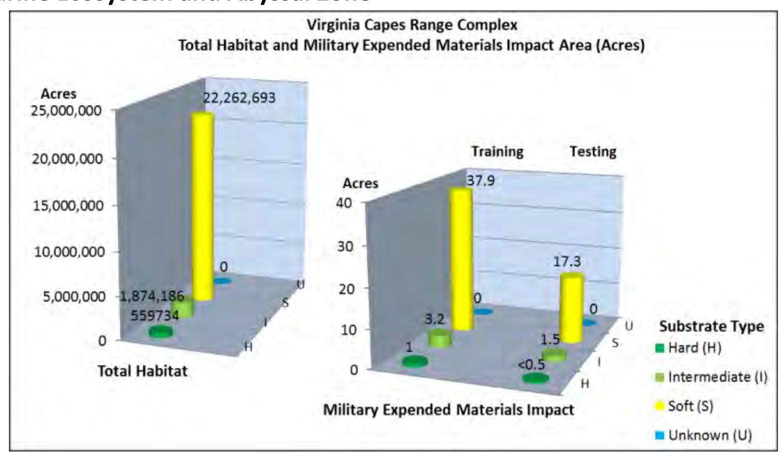
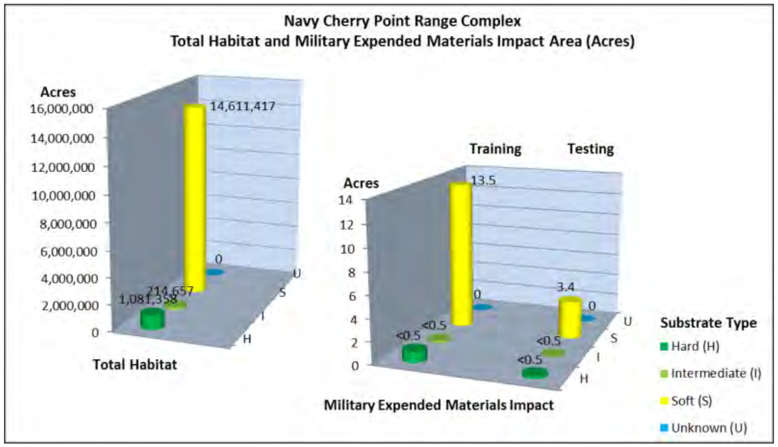
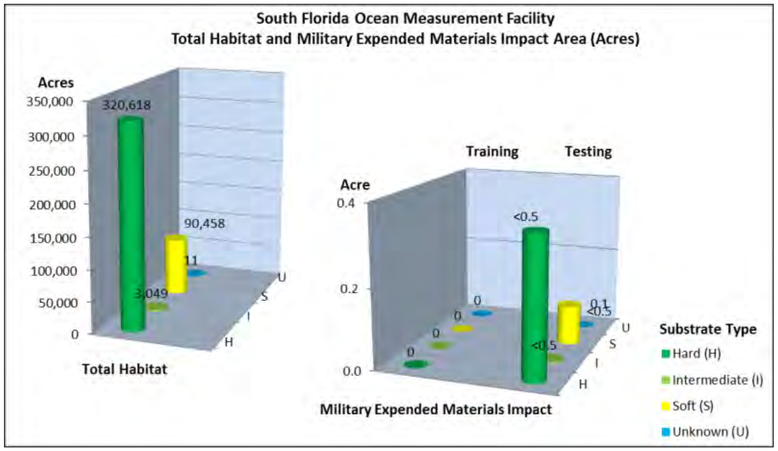


Figure 3.5-15: Alternative 1 – Annual Proportional Impact (Acres) from Military Expended Materials by Substrate Type for Training and Testing Compared to Total Habitat Within the Study Area

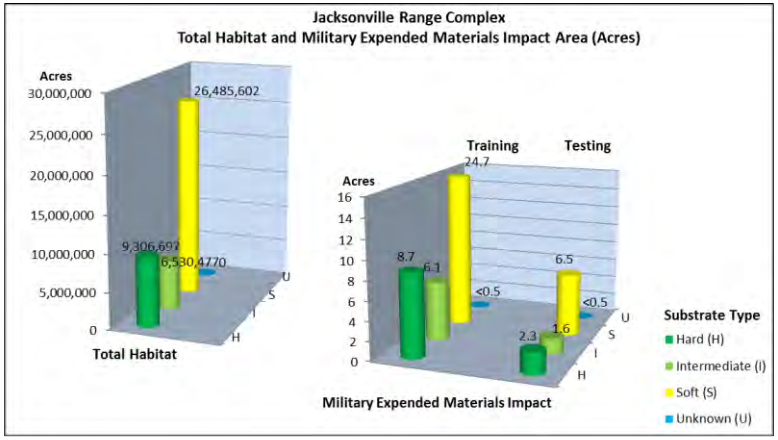
Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems



Southeast U.S. Continental Shelf Large Marine Ecosystem



Southeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone



Caribbean and Gulf of Mexico Large Marine Ecosystems

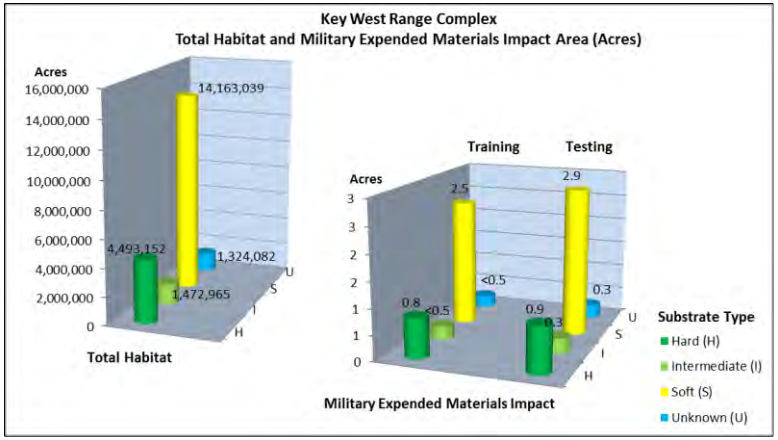
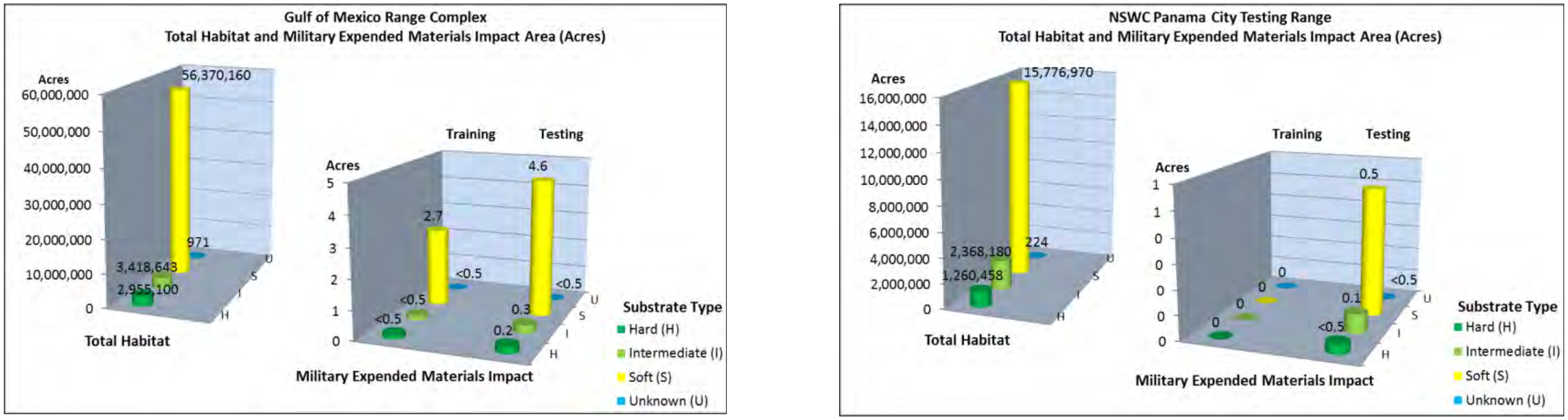


Figure 3.5-15: Alternative 1 – Annual Proportional Impact (Acres) from Military Expended Materials by Substrate Type for Training and Testing Compared to Total Habitat Within the Study Area (continued)

Gulf of Mexico Large Marine Ecosystem



Abyssal Zone

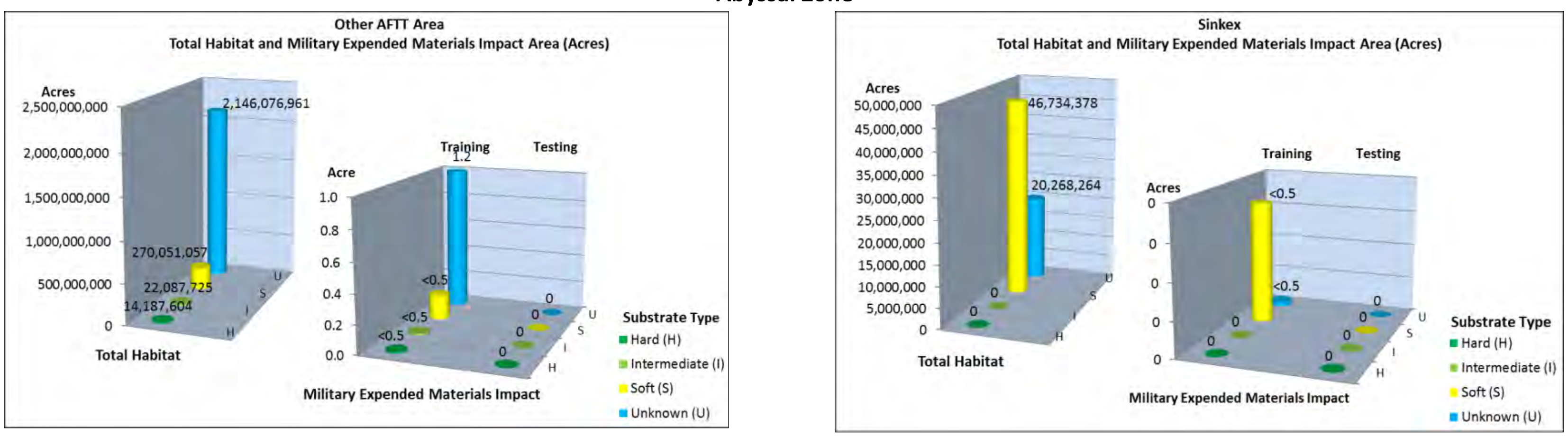
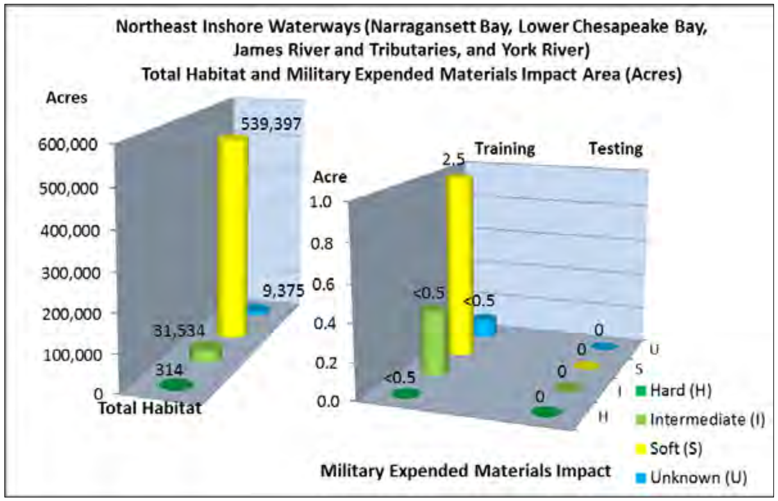


Figure 3.5-15: Alternative 1 – Annual Proportional Impact (Acres) from Military Expended Materials by Substrate Type for Training and Testing Compared to Total Habitat Within the Study Area (continued)

Inshore Waterways



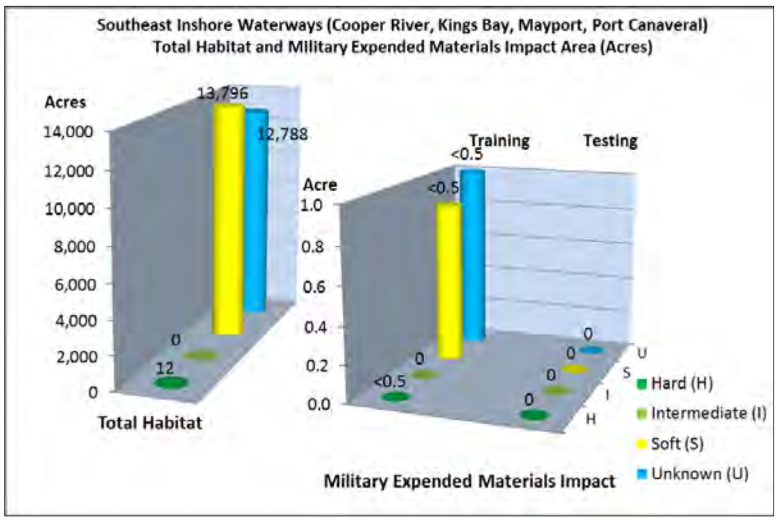


Figure 3.5-15: Alternative 1 – Annual Proportional Impact (Acres) from Military Expended Materials by Substrate Type for Training and Testing Compared to Total Habitat Within the Study Area (continued)

Further, many of the materials used in testing are recovered to some degree: non-explosive torpedoes (100 percent), unmanned aerial systems (depends on the type and exercise), targets (depends on the type and exercise), and mine shapes (depends on the exercise). For the purpose of analysis, if the recovery status was unknown, the item was assumed to be expended. The numbers are also based on a maximum expenditure which is typically not realized in any given year.

As discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources), the Navy will implement mitigation to avoid impacts from military expended materials on habitats in mitigation areas throughout the Study Area. For example, the Navy will not conduct gunnery activities within a specified distance of shallow-water coral reefs. Mitigation for seafloor resources was not included in the quantitative assessment of habitat impacts; however, it will help the Navy further avoid the potential for impacts on habitats from certain activities that involve the use of military expended materials.

3.5.3.4.3.2 Impacts from Military Expended Materials Under Alternative 2

Impacts from Military Expended Materials Under Alternative 2 for Training Activities

Training activities involving military expended materials (Appendix A, Navy Activity Descriptions) would have the potential to impact the marine substrates within the areas the training is occurring. Each range complex was evaluated to determine what the level of impact could be expected under Alternative 2.

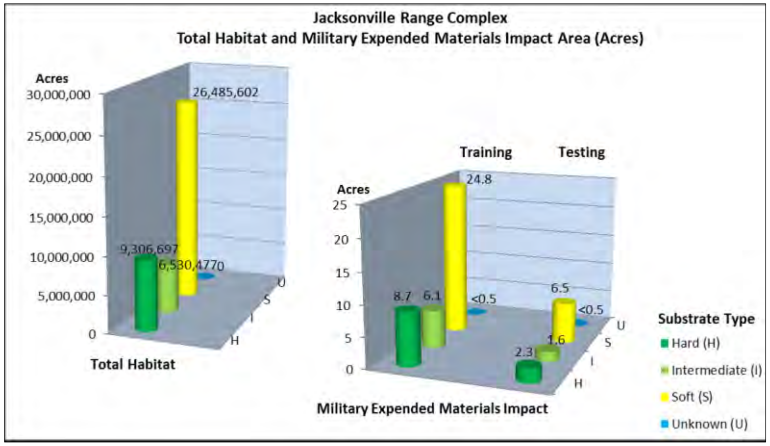
As indicated in Section 3.0.3.3.4.2 (Military Expended Materials), under Alternative 2 the total number of military expended materials would be nearly identical to those analyzed under Alternative 1 (see Appendix F, Military Expended Materials and Direct Strike Impact Analysis), and the primary difference between alternatives would be due to an increase in the amount of materials (e.g., sonobuoys) associated with anti-submarine warfare activities. Activities under Alternative 2 would occur in the same geographic locations using the same types of military expended materials as Alternative 1.

To determine the percentage of the total soft bottom, intermediate bottom, or hard bottom substrate within a training range that may potentially be impacted by military expended materials under a worst case scenario for each of the alternatives, the total impacted area for each training range was divided by the total amount of that particular substrate type within the same testing range. Results of this analysis are provided in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Military expended materials related to training activities under a conservative scenario would not impact more than 0.01 percent of the available soft bottom habitat annually within any of the training ranges. Likewise, the potential impact of the conservative scenario on intermediate bottom habitats within each training range does not exceed 0.01 percent of the total available intermediate bottom. Likewise, the potential impact of the conservative scenario on habitats within each training area, range complex, or other area does not exceed 0.01 percent of the total available hard bottom.

Analysis was conducted in order to determine the proportional impact of military expended material from training on marine habitats in each of the range complexes within the Study Area. Under Alternative 2, impacts would only differ for the Jacksonville and Gulf of Mexico Range Complexes (Figure 3.5-16). Based on the proportional analysis of impacts, military expended material impacts to hard substrate from training activities would be approximately 11.5 acres. Impacts to other substrate types would be approximately10.5, 85.0, and 1.5 acres for intermediate, soft, and unknown substrates, respectively. See Appendix F (Military Expended Materials and Direct Strike Impact Analysis) for detailed analysis of military expended materials impacts from training activities in each Training Area.

Southeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone



Gulf of Mexico Large Marine Ecosystem

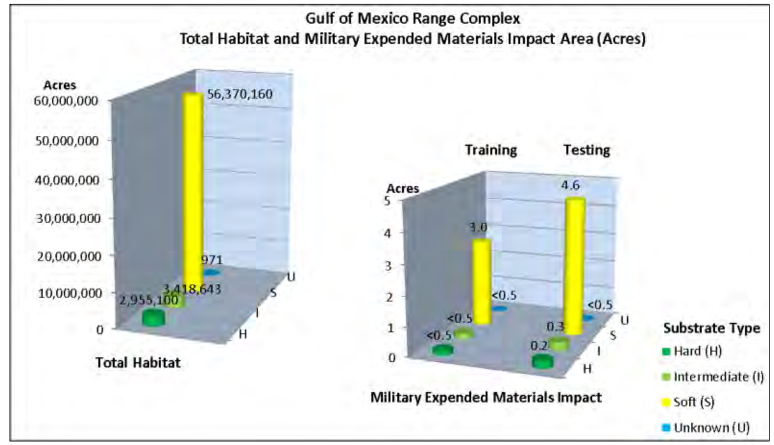


Figure 3.5-16: Alternative 2 – Annual Proportional Impact (Acres) from Military Expended Materials by Substrate Type for Training and Testing Compared to Total Vulnerable Habitat Within the Range Complexes of the Large Marine Ecosystems Within the Study Area

Analysis was conducted to evaluate impacts accumulating over the course of a 5-year period. The analysis assumed that all impacts would accumulate. In reality, soft bottom habitats may recover in the short term where heavier military expended materials are buried under shifting sediments; hard bottom habitats would recover over the long term where hard, stable military expended materials become overgrown with similar organisms. The total proportional impact footprint for impacts from high explosives over a 5-year period would be approximately 58.5, 52.5, and 424.5 acres for hard bottom, intermediate bottom, and soft bottom respectively. Approximately 7.5 acres of unknown habitat would be impacted. However, total impacts would still affect less than 0.04 percent of the total area of each habitat type (hard, intermediate, and soft) would be impacted. Details of this analysis can be found in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Given that the probability of these worst case scenarios occurring is highly unlikely, the actual impact of military expended materials within each range complex under Alternative 2 on either hard bottom or soft bottom substrates will be even less than shown in Figure 3.5-16.

Further, many of the military expended materials would be recovered, including, torpedoes, unmanned aerial systems, targets, mine shapes, and instruments.

Impacts from Military Expended Materials Under Alternative 2 for Testing Activities

Testing activities involving military expended materials (Section 3.0.3.3.4, Physical Disturbance and Strike Stressors, and Appendix A, Navy Activity Descriptions) would have the potential to impact the marine substrates within the areas the testing is occurring. Each range complex and testing range was evaluated to determine what the level of impact could be expected under Alternative 2.

As indicated in Section 3.0.3.3.4.2 (Military Expended Materials), under Alternative 2 the total number of military expended materials would be very similar to that under Alternative 1 (see Appendix F, Military Expended Materials and Direct Strike Impact Analysis). However, there are several types of activities under Alternative 2 that would require a slight increase in military expended materials. For example, under Alternative 2 there would be increases in torpedoes, rockets, missiles, medium-caliber projectiles, and torpedo accessories, along with sonobuoys associated with anti-submarine warfare. Activities under Alternative 2 would occur in the same geographic locations using the same types of military expended materials as Alternative 1.

To determine the percentage of the total soft bottom, intermediate bottom, or hard bottom substrate within a testing range that may potentially be impacted by military expended materials under a worst case scenario for each of the alternatives, the total impacted area for each testing range was divided by the total amount of that particular substrate type within the same testing range. Results of this analysis are provided in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Military expended materials related to testing activities under a conservative scenario would not impact more than 0.01 percent of the available soft bottom habitat annually within any of the testing ranges. Likewise, the potential impact of the conservative scenario on intermediate bottom habitats within each testing range does not exceed 0.01 percent of the total available intermediate bottom. The potential impact of the conservative scenario on habitats within each testing range does not exceed 0.1 percent of the total available hard bottom.

Analysis was conducted in order to determine the proportional impact of military expended material from testing on marine habitats in each of the range complexes within the Study Area. Based on the proportional analysis of impacts, military expended material impacts to hard substrate from training activities would be 5.0 acres. Impacts to other substrate types would be approximately 5.0, 42.0, and 1.5 acres for intermediate, soft, and unknown substrates, respectively. The total area of substrate potentially impacted due to decelerators/parachutes expended would increase by about 0.7 acre compared to Alternative 1, primarily in the Northeast Range Complex. See Appendix F (Military Expended Materials and Direct Strike Impact Analysis) for detailed analysis of explosive impacts from training activities in each training area.

Analysis was conducted to evaluate impacts accumulating over the course of a 5-year period. The analysis assumed that all impacts would accumulate. In reality, over time, some habitat would recover as soft substrates are dynamic systems and craters could refill. The total proportional impact footprint for impacts from high explosives over a 5-year period would be approximately 24.5, 26.0, and 210.0 acres for hard bottom, intermediate bottom, and soft bottom respectively. Approximately 1.5 acres of unknown habitat would be impacted. However, total impacts would still affect less than 0.05 percent of the total area of each habitat type (hard, intermediate, and soft) would be impacted. Details of this analysis can be found in Appendix F (Military Expended Materials and Direct Strike Impact Analysis).

Given that the probability of these worst case scenarios occurring is highly unlikely, the actual impact of military expended materials within each range complex under Alternative 2 on either hard bottom or soft bottom substrates will be even less than shown in Figure 3.5-15.

Further, many of the military expended materials would be recovered, including torpedoes, unmanned aerial systems, targets, mine shapes, and instruments.

3.5.3.4.3.3 Impacts from Military Expended Materials Under the No Action Alternative

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

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

3.5.3.4.4 Impacts from Seafloor Devices

The types of activities that use seafloor devices are discussed in Appendix B (Activity Stressor Matrices) and where they would be used and how many activities would occur under each alternative are discussed in Section 3.0.3.3.4.3 (Seafloor Devices). Seafloor devices include items that are placed on, dropped on, or moved along the substrate for a specific purpose, and include mine shapes, anchor blocks, vessel anchors, bottom-placed instruments, bottom-crawling unmanned underwater vehicles, and bottom placed targets that are recovered (not expended). Mine shapes are typically deployed via surface vessels or fixed-wing aircraft. These items can damage fragile abiotic or biogenic structures on the bottom, temporarily cover and effectively replace an area of bottom, and resuspend sediment when deployed/retrieved.

3.5.3.4.4.1 Impacts from Seafloor Devices Under Alternative 1

Impacts from Seafloor Devices Under Alternative 1 for Training Activities

As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, seafloor devices are deployed in the Northeast and Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems, as well as Gulf Stream Open Ocean Area—specifically within the Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes and Naval Surface Warfare Center Panama City Testing Range. Specific bays and inshore waters where seafloor devices are deployed include Boston, Massachusetts; Earle, New Jersey; Delaware Bay, Delaware; Hampton Roads, Lower Chesapeake Bay, James River and tributaries, and York River, Virginia; Wilmington and Morehead City, North Carolina; Savannah, Georgia; Mayport, Port Canaveral, Truman Harbor, Demolition Key, and Tampa, Florida; and Beaumont and Corpus Christi, Texas.

Activities involving seafloor devices have the potential to impact bottom habitats. While hard bottom exists in all these areas, activities in the Virginia Capes Range Complex, Navy Cherry Point Range Complex, and particularly the Jacksonville Range Complex have the greatest potential to impact hard bottom. Mine shapes or other stationary targets and anchors are typically recovered within 7 to 30 days following the completion of the training or testing events. As a result of their temporary nature, recovered mine shapes do not permanently impact the substrate on which they are placed, but will temporarily impair the ability of the substrate to function as a habitat for as long as the mine shape and anchor is in place. The impairment is due to the temporary covering by artificial substrate along with changes in the bathymetry around the structures due to scouring and deposition patterns around objects on a soft bottom. Additionally, many targets used in inshore waters are placed either pierside or at beachfront locations where the substrate is already disturbed by dredging (for pierside locations) or by nearshore currents and wave action (for beach-front locations).

Potential impacts of precision anchoring are qualitatively different from other seafloor devices because the activity involves repeated disturbance to the same area of seafloor. Precision anchoring training exercises involve releasing of anchors in designated locations. The intent of these training exercises is to practice anchoring the vessel within 300 ft. of the planned anchorage location. These training activities typically occur within predetermined shallow water anchorage locations near ports with seafloors consisting of soft bottom substrate. The level of impact to the soft sediments would depend on the size of the anchor used, which would vary according to vessel type. As most of these activities occur in areas along navigation channels subject to strong currents and shifting sediment, disturbed areas would quickly return to pre-disturbance conditions. The Navy will implement mitigation that includes not conducting precision anchoring (except in designated anchorages) within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks to avoid potential impacts from seafloor devices on habitats in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). Mitigation for seafloor resources was not included in the quantitative assessment of habitat impacts; however, it will help the Navy further avoid the potential for impacts on habitats from precision anchoring activities.

Crawlers are fully autonomous, battery-powered amphibious vehicles used for functions such as reconnaissance missions in territorial waters. These devices are used to classify and map underwater mines in shallow water areas. The crawler is capable of traveling 2 ft. per second along the seafloor and can avoid obstacles. The crawlers are equipped with various sonar sensors and communication equipment that enable these devices to locate and classify underwater objects and mines while rejecting miscellaneous clutter that would not pose a threat.

Crawlers move over the surface of the seafloor and would not harm or alter any hard substrates encountered; therefore hard bottom habitat would not be impaired. However, fragile abiotic or biogenic structures could be harmed by the crawlers moving over the substrate (refer to living resources sections for analysis). In soft substrates, crawlers may leave a trackline of depressed sediments approximately 2 ft. wide (the width of the device) in their wake. However, since these crawlers operate in shallow water, any disturbed sediments would be redistributed by wave and tidal action shortly (days to weeks) following the disturbance. Therefore, disturbance would not impair the ability of soft sediment to function as a habitat.

The impact of seafloor devices on marine habitats from Alternative 1 training activities is likely to be inconsequential because: (1) the area exposed to the stressor is extremely small relative to overall availability of habitat of each type, (2) the activities are dispersed such that with the exception of precision anchoring activities, few habitats would be exposed to multiple events, (3) impacts would be localized and those involving soft bottom would likely be temporary due to the dynamic nature of the habitats, and (4) sensitive habitats would tend to be avoided due to snagging or entanglement that could hinder recovery of the device. Activities involving seafloor devices are not expected to yield any discernable impacts on the overall availability or quality of habitat.

Impacts from Seafloor Devices Under Alternative 1 for Testing Activities

Under Alternative 1, the use of seafloor devices occurs throughout the Study Area. Seafloor devices are employed in all range complexes. Crawlers would be used in the northeast in Narragansett Bay and waters used for testing by the Naval Undersea Warfare Center Division, Newport Testing Range; off the east coast of Florida at the South Florida Ocean Measurement Facility Testing Range; and at the Gulf of Mexico testing ranges for the Naval Surface Warfare Center, Panama City Division Testing Range. Testing activities involving the use of bottom crawling, unmanned underwater vehicles within the South Florida Ocean Measurement Facility Testing Range would be limited to the Port Everglades Restricted Anchorage Area (Section 2.1.6.2, Sea and Undersea Space). In other testing areas, bottom habitats would be exposed to strike and disturbance in the relatively small area transited by bottom-crawling unmanned underwater vehicles.

Testing activities involving the use of anchor blocks, which are used to moor minefield targets and shapes and are deployed and recovered, have the potential to impact bottom habitat throughout the Study Area. At the conclusion of the testing event, the minefield targets and shapes are typically recovered, but may be left in place.

Impacts to habitats from Alternative 1 testing activities are likely to be similar to those discussed above for training exercises. The impact of seafloor devices on marine habitats is likely to be inconsequential because: (1) the area exposed to the stressor is extremely small relative to overall availability of habitat of each type, (2) the activities are dispersed such that with the exception of precision anchoring activities, few habitats would be exposed to multiple events, (3) impacts would be localized and those involving soft bottom would likely be temporary due to the dynamic nature of the habitats, and (4) sensitive habitats would tend to be avoided due to snagging or entanglement that could hinder recovery of the device. Activities involving seafloor devices are not expected to yield any discernable impacts on the overall availability or quality of habitat.

The Navy will implement mitigation to avoid potential impacts from seafloor devices on habitats in mitigation areas within the South Florida Ocean Measurement Facility, as discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources). For example, the Navy will use real-time geographic information system and Global Positioning System (along with remote sensing verification) data during deployment, installation, and recovery of anchors and mine-like objects to avoid impacts on shallow-water coral reefs and live hard bottom.

3.5.3.4.4.2 Impacts from Seafloor Devices Under Alternative 2

Impacts from Seafloor Devices Under Alternative 2 for Training Activities

As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 2, use of seafloor devices under Alternative 2 would be the same as described for Alternative 1 and occur in all large marine ecosystems, as well as Gulf Stream Open Ocean Area and in inshore waterways. Specific bays and inshore waters could include Boston, Massachusetts; Sandy Hook Bay, Earle, New Jersey; Delaware Bay, Delaware; lower Chesapeake Bay, Hampton Roads, Virginia; Beaufort Inlet Channel, Morehead City, North Carolina; Cape Fear River, Wilmington, North Carolina; St. Andrew Bay, Panama City, Florida; Sabine Lake, Beaumont, Texas; and Corpus Christi Bay, Corpus Christi, Texas.

Impacts to habitats from training activities under Alternative 2 are likely to be the same as those discussed above for Alternative 1 training exercises. The number of devices and locations in which they would be used would be the same. The impact of seafloor devices on marine habitats is likely to be inconsequential because: (1) the area exposed to the stressor is extremely small relative to overall availability of habitat of each type, (2) the activities are dispersed such that with the exception of precision mooring activities, few habitats would be exposed to multiple events, (3) impacts would be localized and those involving soft bottom would likely be temporary due to the dynamic nature of the habitats, and (4) sensitive habitats would tend to be avoided due to snagging or entanglement that could hinder recovery of the device. Activities involving seafloor devices are not expected to yield any discernable impacts on the overall availability or quality of habitat.

Impacts from Seafloor Devices Under Alternative 2 for Testing Activities

Under Alternative 2, the use of seafloor devices occurs in the Northeast, and Southeast U.S. Continental Shelf Large Marine Ecosystems as well as Gulf Stream Open Ocean Area—specifically within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, and Key West Range Complexes; Naval Undersea Warfare Center Division, Newport Testing Range, South Florida Ocean Measurement Facility Testing Range, Naval Surface Warfare Center, and the Panama City Division Testing Range and anywhere in the Gulf of Mexico.

Impacts to habitats from testing activities under Alternative 2 are likely to be similar to those discussed above for Alternative 1 testing exercises. The number of testing activities involving seafloor devices is only slightly increased (approximately 0.5 percent increase) from Alternative 1. The only locations where activities would increase are Virginia Capes Range Complex and Naval Surface Warfare Center Panama City Testing Range, where 10 and 9 additional activities would occur at each location, respectively. Impact of seafloor devices on marine habitats is likely to be inconsequential because: (1) the area exposed to the stressor is extremely small relative to overall availability of habitat of each type, (2) the activities are dispersed such that with the exception of precision mooring activities, few habitats would be exposed to multiple events, and (3) impacts would be localized and those involving soft bottom would likely be temporary due to the dynamic nature of the habitats. Activities involving seafloor devices are not expected to yield any discernable impacts on the overall availability or quality of habitat.

3.5.3.4.4.3 Impacts from Seafloor Devices Under the No Action Alternative

Impacts from Seafloor Devices Under the No Action Alternative for Training and Testing Activities

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

3.5.3.4.5 Impacts from Pile Driving

Pile driving and removal would involve driving of piles into soft substrate with an impact hammer. Pile driving may have the potential to impact soft bottom habitats temporarily during driving, removal, and in the short term thereafter.

3.5.3.4.5.1 Impacts from Pile Driving Under Alternative 1

Impacts from Pile Driving Under Alternative 1 for Training Activities

Under Alternative 1, Elevated Causeway System training would include pile driving and removal which could occur once per year in the nearshore and surf zone at either or both of the following locations: Chesapeake Bay area or Navy Cherry Point Range Complex. While pile driving and removal may have the potential to impact soft bottom habitat, the impacts would be extremely limited since the number of piles is relatively small, and the duration is short (20 days for assembly and 10 days for disassembly). Piles would remain in the water for up to 60 days. Since pile driving would occur in the nearshore and surf zone areas, the dynamic nature of the soft bottom habitat is likely to return to its previous state shortly following removal of the temporary piles. However, the dispersed larvae forming new hard bottom communities may attach to the temporary structures instead of more permanent structures (see Section 3.4, Invertebrates, for details).

Impacts from Pile Driving Under Alternative 1 for Testing Activities

Pile driving does not occur under testing activities for Alternative 1 and will not be analyzed in this section.

3.5.3.4.5.2 Impacts from Pile Driving Under Alternative 2

Impacts from Pile Driving Under Alternative 2 for Training Activities

Under Alternative 2, Elevated Causeway System training would include pile driving and removal which could occur once per year in the nearshore and surf zone at one of the following locations: Chesapeake Bay area or Navy Cherry Point Range Complex. While pile driving and removal may have the potential to impact soft bottom habitat, the impacts would be extremely limited since the number of piles is relatively small, and the duration is short (20 days for assembly and 10 days for disassembly). Piles would remain in the water for up to 60 days. Since pile driving would occur in the nearshore and surf zone areas, the dynamic nature of the soft bottom habitat is likely to return to its previous state shortly following removal of the temporary piles.

Impacts from Pile Driving Under Alternative 2 for Testing Activities

Pile driving does not occur under testing activities for Alternative 2 and will not be analyzed in this section.

3.5.3.4.5.3 Impacts from Pile Driving Under the No Action Alternative

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

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

3.5.3.5 Entanglement Stressors

Entanglement stressors are not applicable to habitats due to the lack of mobility capabilities of habitats and will not be analyzed in this section.

3.5.3.6 Ingestion Stressors

Ingestion stressors are not applicable to habitats due to the lack of ingestion capabilities of habitats and will not be analyzed in this section.

3.5.3.7 Secondary Stressors

Secondary stressors are not applicable to habitats as they are not susceptible to impacts from secondary stressors and will not be analyzed in this section.

3.5.4 Summary of Potential Impacts on Habitats

3.5.4.1 Combined Impacts of All Stressors Under Alternative 1

Of all the potential stressors, only explosives on or near the bottom and military expended materials have any measureable potential to impact marine substrates as habitat for biological communities. The impact area for in-water explosions and military expended materials were all much less than 1 percent of the total area of documented soft bottom or hard bottom in their respective training or testing areas for each mapped substrate type, in any range complex, over 1 year. Furthermore, impacts are expected to be negligible for unknown substrate type habitats. The impacts are unlikely to persist in most cases. Large and dense military expended material (e.g., anchor blocks, large caliber projectile casings, non-explosive bombs) deposited on the bottom along the outer continental shelf would be the most persistent. However, soft bottom habitats may recover in the short term where heavier military expended materials are buried under shifting sediments; hard bottom habitats would recover over the long term where hard, stable military expended materials become overgrown with similar organisms.

The combined impact area of explosive stressors, physical disturbances, and strike stressors proposed for training and testing events in Alternative 1 would have minimal impact on the ability of soft bottom, intermediate bottom, or hard bottom to serve their function as habitat. The total area of mapped hard bottom (Figure 3.5-1 through Figure 3.5-4) in the Study Area is over 35,734,150 acres, which dwarfs the estimated 17.5 acres of potential impacts. Training activities under Alternative 1 would have a total footprint of potential impact across all habitat types of 108.5 acres from military expended materials and 8.5 acres from explosive detonations. This also represents less than 0.01 percent of the bottom habitat within the Study Area. Testing activities under Alternative 1 would have a total footprint of potential impact of 52.5 acres from military expended materials and 9.0 acres from explosive detonations. This represents less than 0.01 percent of the bottom habitat within the Study Area. The combined total proportional impact for training and testing is primarily to soft bottom habitat, much less to hard and intermediate substrate habitats, and very little to areas with unknown substrate type (Figure 3.5-17). See Appendix F (Military Expended Materials and Direct Strike Impact Analysis) for detailed impact analysis.

3.5.4.2 Combined Impacts of All Stressors Under Alternative 2

The combined effects of explosive stressors, physical disturbances, and strike stressors proposed for training and testing events in Alternative 2 would have minimal impact on the ability of soft bottom, intermediate bottom, or hard bottom to function as habitat. The total area of mapped hard bottom (Figure 3.5-1 through Figure 3.5-4) in the Study Area is over 35,734,150 acres, which dwarfs the estimated 17.5 acres of potential impacts. Training activities under Alternative 2 would have a total footprint of potential impact of 108.5 acres across all habitat types from military expended materials and 8.5 acres from explosive detonations. This represents less than 0.01 percent of the bottom habitat within the Study Area. Testing activities under Alternative 2 would have a total footprint of potential impact of 52.5 acres from military expended materials and 10.5 acres from explosive detonations. This also represents less than 0.01 percent of the bottom habitat within the Study Area. The combined total proportional impact for training and testing is primarily to soft bottom habitat, much less to hard bottom and intermediate bottom substrate habitats, and very little to areas with unknown substrate type (Figure 3.5-18). See Appendix F (Military Expended Materials and Direct Strike Impact Analysis) for detailed impact analysis.

3.5.4.3 Combined Impacts of All Stressors Under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various explosives and physical disturbance and strike stressors (e.g., in-water detonations, military expended materials, seafloor devices, vessels and in-water devices, and pile driving) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

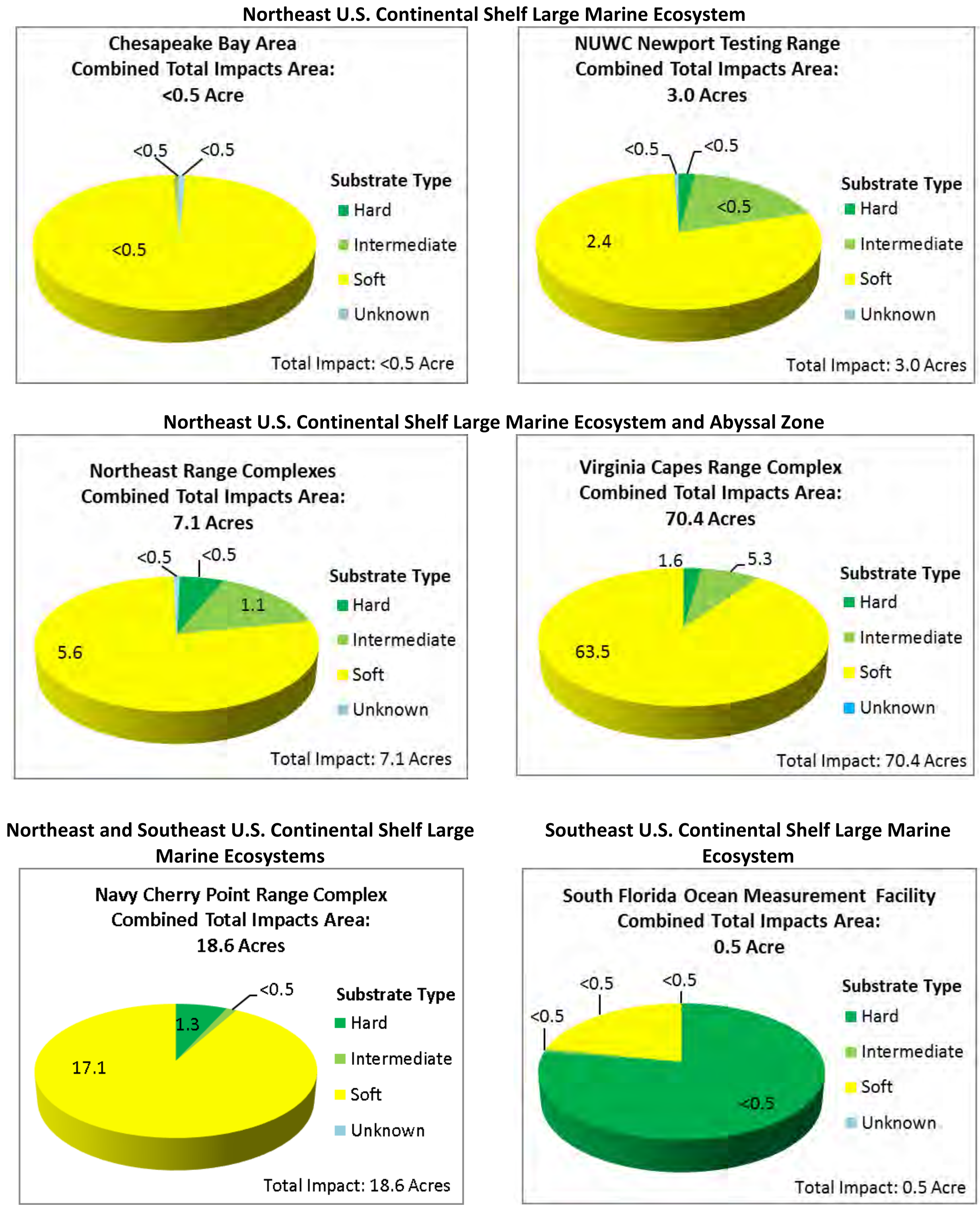
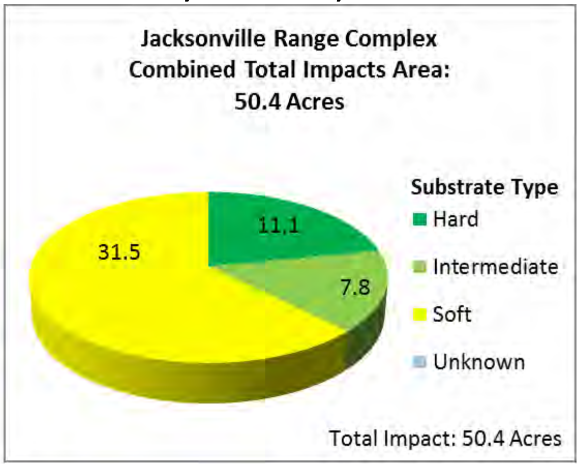
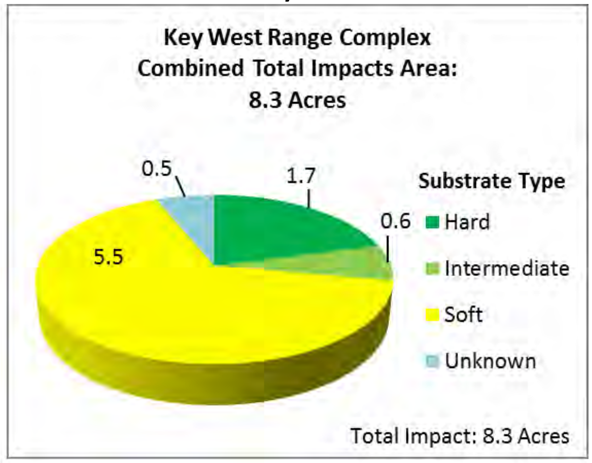


Figure 3.5-17: Alternative 1 – Annual Combined Proportional Impact (Acres) from Explosives and Military Expended Materials for Training and Testing Within the Study Area

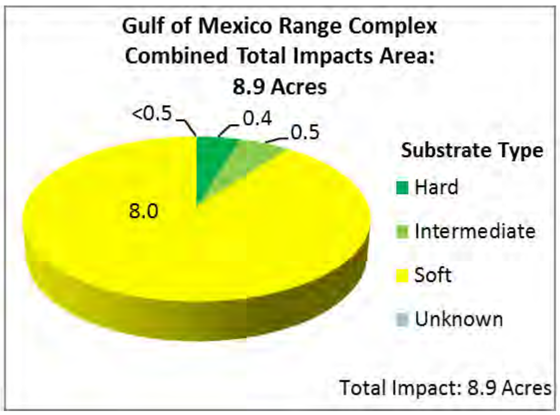
Southeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone

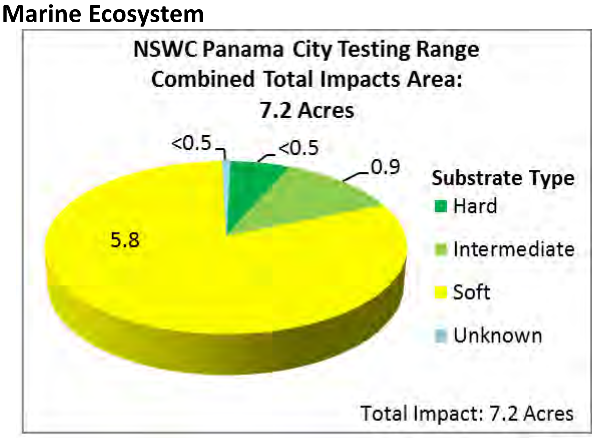


Caribbean and Gulf of Mexico Large Marine Ecosystems

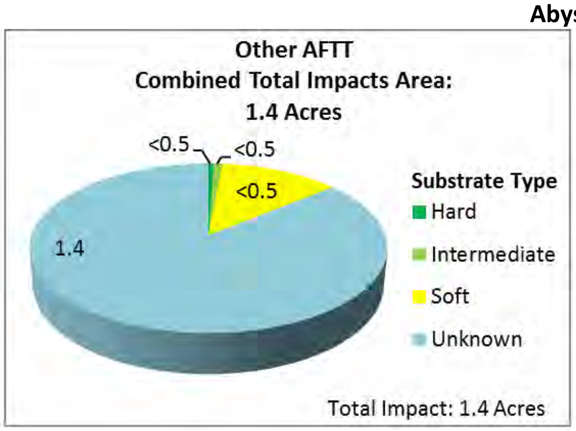


Gulf of Mexico Large Marine Ecosystem





Abyssal Zone



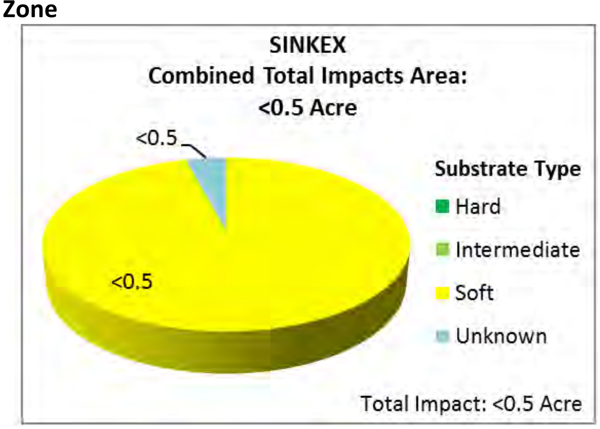
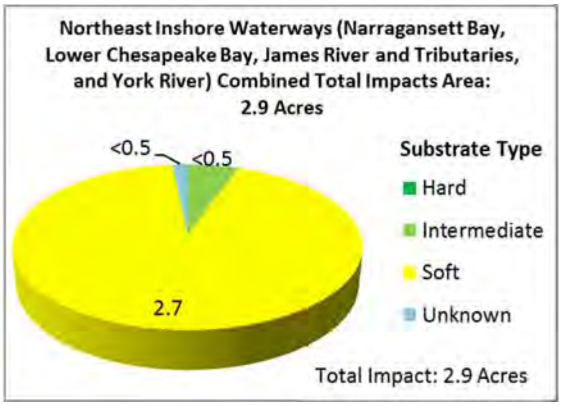


Figure 3.5-17: Alternative 1 – Annual Combined Proportional Impact (Acres) from Explosives and Military Expended Materials for Training and Testing Within the Study Area (continued)

Inshore Waterways



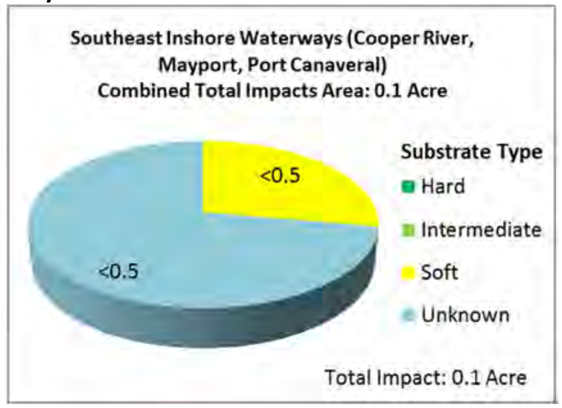
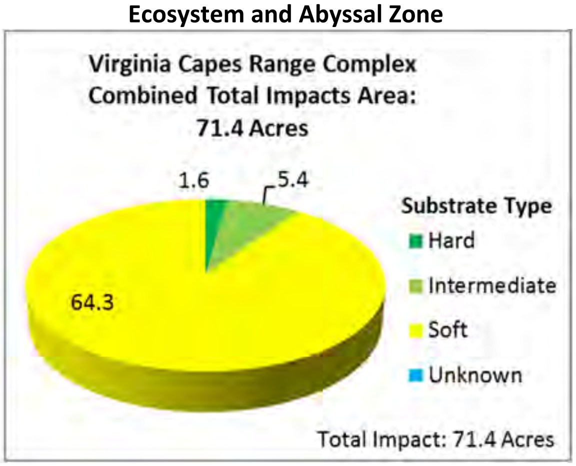
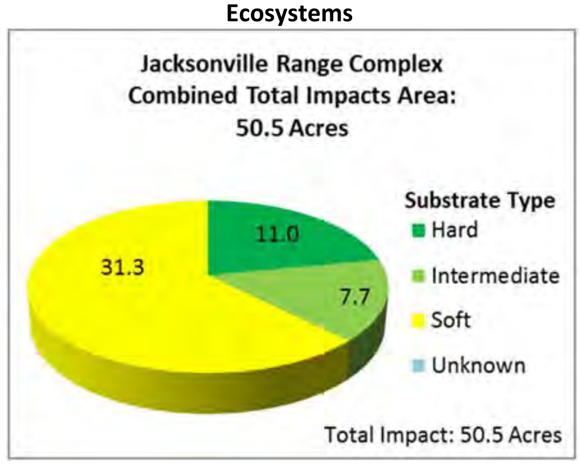


Figure 3.5-17: Alternative 1 – Annual Combined Proportional Impact (Acres) from Explosives and Military Expended Materials for Training and Testing Within the Study Area (continued)

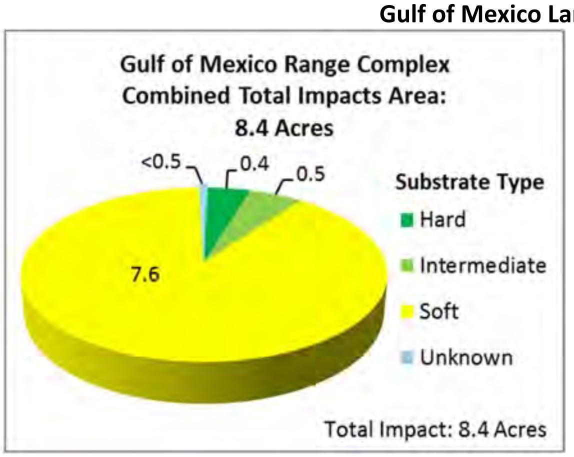
Southeast U.S. Continental Shelf Large Marine Ecosystem and Abyssal Zone



Caribbean and Gulf of Mexico Large Marine Ecosystems



Gulf of Mexico Large Marine Ecosystem



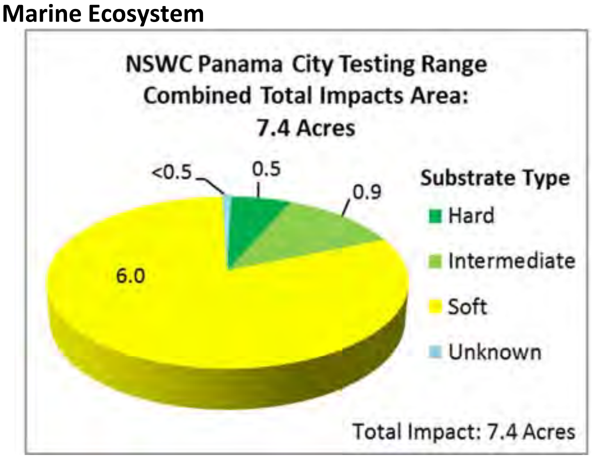


Figure 3.5-18: Alternative 2 – Annual Combined Proportional Impact (Acres) from Explosives and Military Expended Materials for Training and Testing Within the Study Area

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

TABLE OF CONTENTS

List of Figures

List of Tables

3.6 FISHES

FISHES SYNOPSIS

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

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

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FISHES SYNOPSIS

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

3.6.1 Introduction

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

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

3.6.2 AFFECTED ENVIRONMENT

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

3.6.2.1 General Background

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

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

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

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

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

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

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

3.6.2.1.1 Habitat Use

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

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

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

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

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

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

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

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

3.6.2.1.2 Movement and Behavior

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

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

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

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

3.6.2.1.3 Hearing and Vocalization

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

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

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

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

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

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

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

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

3.6.2.1.4 General Threats

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

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

3.6.2.1.4.1 Water Quality

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

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

Pollution

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

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

Oil Spills

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

3.6.2.1.4.2 Commercial and Recreational Activities

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

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

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

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

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

Anthropogenic Noise

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

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

3.6.2.1.4.3 Disease and Parasites

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

3.6.2.1.4.4 Invasive Species

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

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

3.6.2.1.4.5 Climate Change

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

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

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

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

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

3.6.2.1.4.6 Marine Debris

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

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

3.6.2.2 Endangered Species Act-Listed Species

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.6.2.2.1 Atlantic Salmon (*Salmo salar*)

3.6.2.2.1.1 Status and Management

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

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

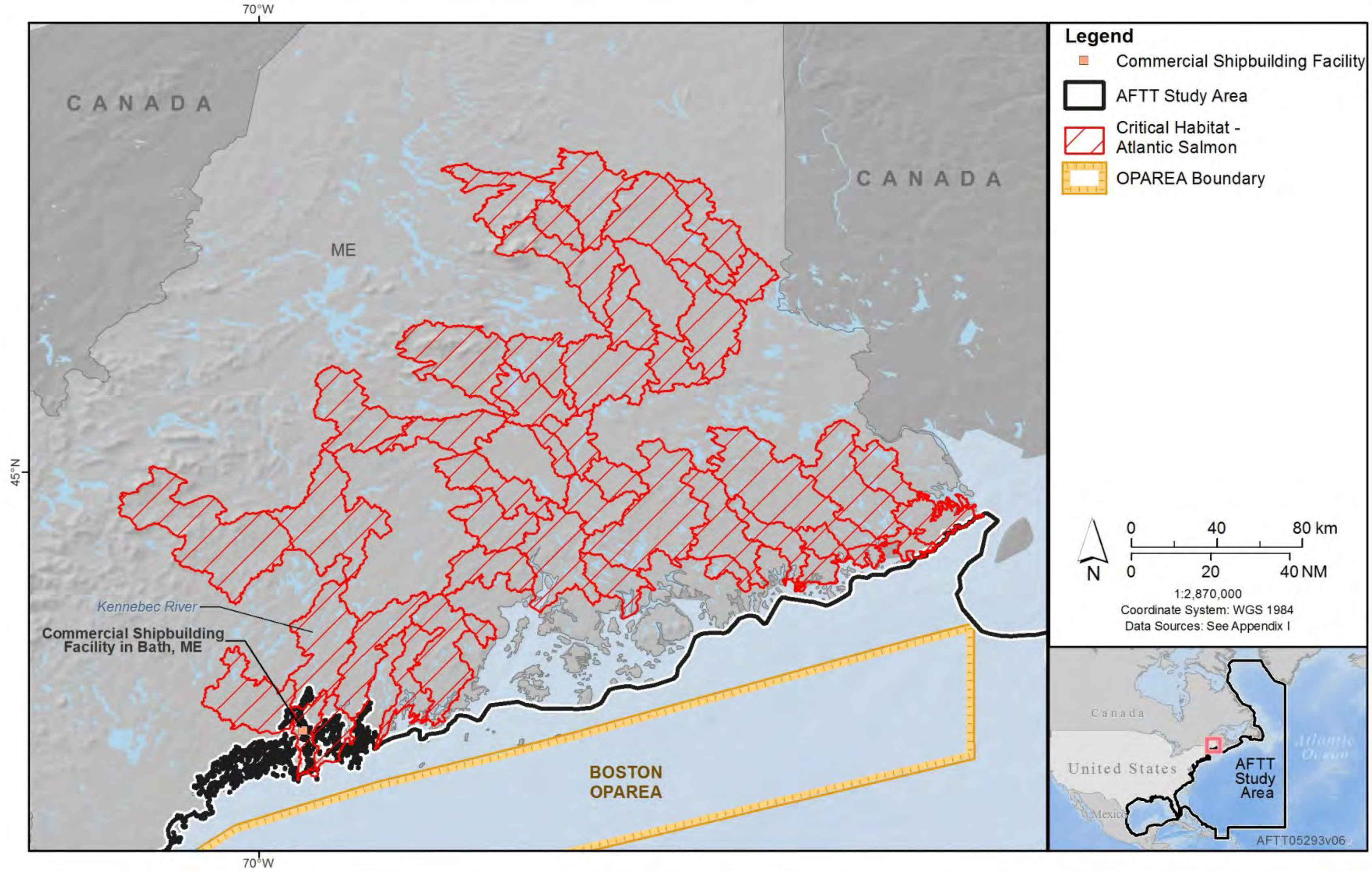
1. Substrate of suitable size and quality; rivers and streams of adequate flow, depth, water temperature and water quality;
2. Rivers, streams, lakes and ponds with sufficient space and diverse, abundant food resources to support growth and survival;
3. Waterways that allow for free migration of both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

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

3.6.2.2.1.2 Habitat and Geographic Range

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

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



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

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

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

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

3.6.2.2.1.3 Population Trends

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

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

3.6.2.2.1.4 Predator and Prey Interactions

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

3.6.2.2.1.5 Species-Specific Threats

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

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

3.6.2.2.2 Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)

3.6.2.2.2.1 Status and Management

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

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

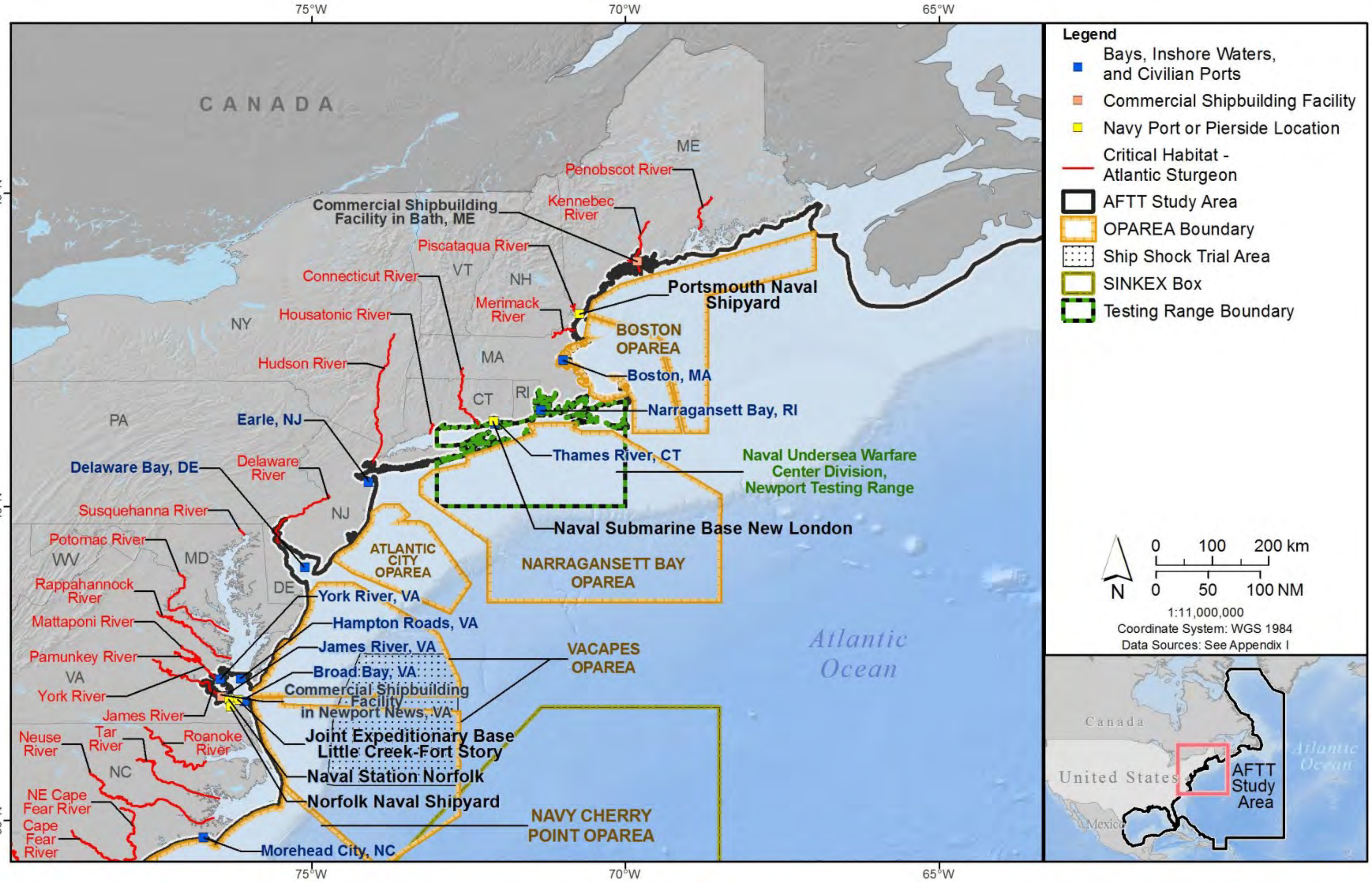
Critical habitat for the Gulf of Maine Distinct Population Segments of Atlantic sturgeon has been designated in the Penobscot, Kennebec, Androscoggin, and Piscataqua rivers in Maine, Piscataqua River in New Hampshire, and Merrimack River in Massachusetts (82 *Federal Register* 39160).

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

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

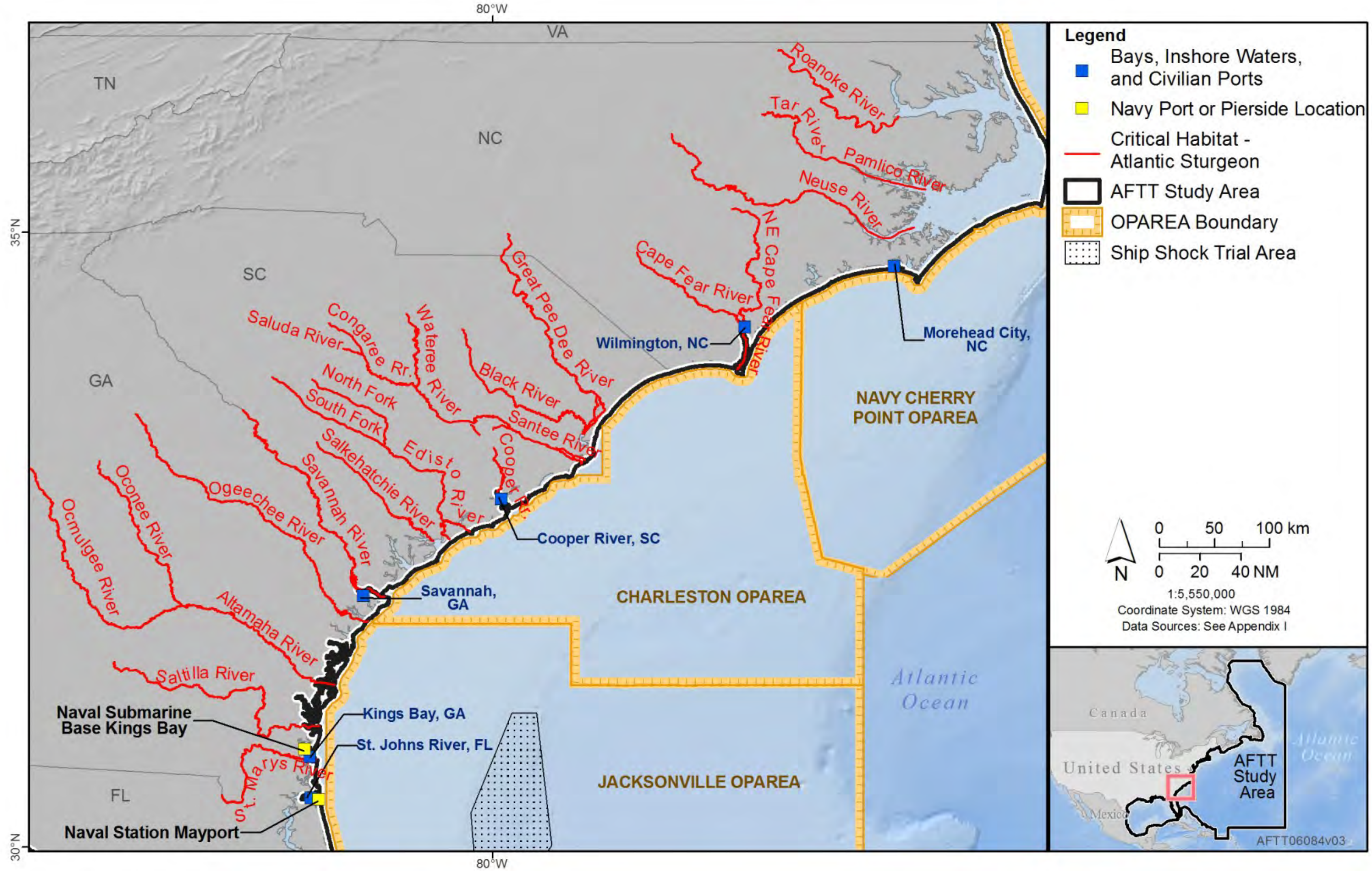
Critical habitat for the Carolina Distinct Population Segment of Atlantic sturgeon has been designated in the Roanoke, Tar-Pamlico, Neuse, Northeast Cape Fear, Cape Fear, and Pee Dee rivers in North Carolina; and Pee Dee, Black, Santee, and Cooper rivers in South Carolina (82 *Federal Register* 39160).

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



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

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



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

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

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

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

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

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

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

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

      i. Spawning;

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

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

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

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

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

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

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

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

   a. Spawning;

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

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

3.6.2.2.2.2 Habitat and Geographic Range

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

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

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

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

3.6.2.2.2.3 Population Trends

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

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

3.6.2.2.2.4 Predator and Prey Interactions

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

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

3.6.2.2.2.5 Species-Specific Threats

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

3.6.2.2.3 Largetooth Sawfish (*Pristis pristis*)

3.6.2.2.3.1 Status and Management

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

3.6.2.2.3.2 Habitat and Geographic Range

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

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

3.6.2.2.3.3 Population Trends

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

3.6.2.2.3.4 Predator and Prey Interactions

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

3.6.2.2.3.5 Species-Specific Threats

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

3.6.2.2.4 Shortnose Sturgeon (*Acipenser brevirostrum*)

3.6.2.2.4.1 Status and Management

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

3.6.2.2.4.2 Habitat and Geographic Range

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

3.6.2.2.4.3 Population Trends

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

3.6.2.2.4.4 Predator and Prey Interactions

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

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

3.6.2.2.4.5 Species-Specific Threats

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

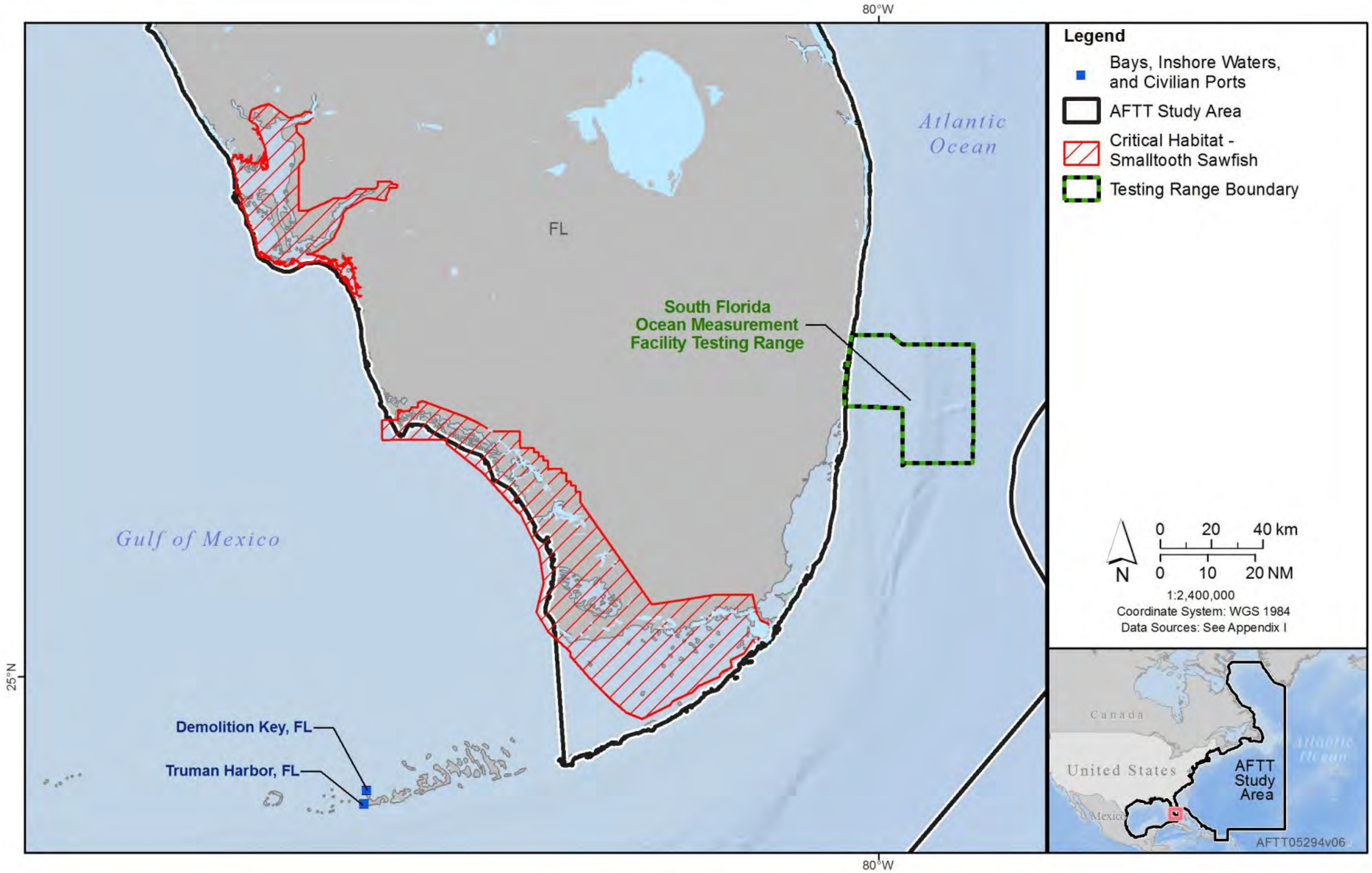
3.6.2.2.5 Smalltooth Sawfish (*Pristis pectinata*)

3.6.2.2.5.1 Status and Management

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

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

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



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

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

3.6.2.2.5.2 Habitat and Geographic Range

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

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

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

3.6.2.2.5.3 Population Trends

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

3.6.2.2.5.4 Predator and Prey Interactions

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

3.6.2.2.5.5 Species-Specific Threats

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

3.6.2.2.6 Giant Manta Ray (*Manta birostris*)

3.6.2.2.6.1 Status and Management

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

3.6.2.2.6.2 Habitat and Geographic Range

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

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

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

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

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

3.6.2.2.6.3 Population Trends

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

3.6.2.2.6.4 Predator and Prey Interactions

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

3.6.2.2.6.5 Species-Specific Threats

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

3.6.2.2.7 Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)

3.6.2.2.7.1 Status and Management

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

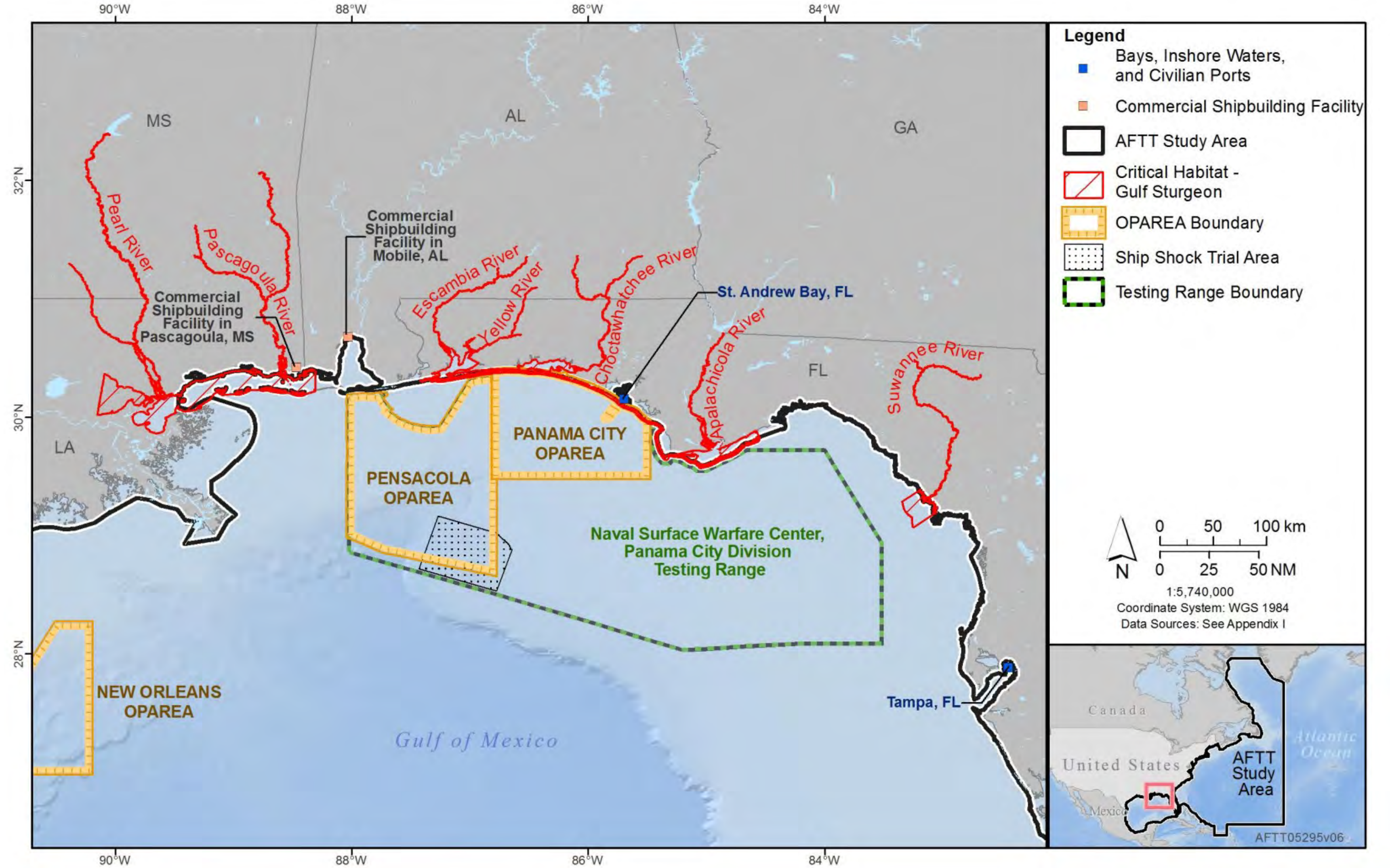
In September 2009, NMFS designated critical habitat for Gulf sturgeon within and adjacent to the states of Louisiana, Mississippi, Alabama, and Florida (82 *Federal Register* 39160; Figure 3.6-5). The physical and biological features essential for the conservation of Gulf sturgeon were determined to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

The physical and biological features include:

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

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

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



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

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

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

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

3.6.2.2.7.2 Habitat and Geographic Range

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

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

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

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

3.6.2.2.7.3 Population Trends

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

3.6.2.2.7.4 Predator and Prey Interactions

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

3.6.2.2.7.5 Species-Specific Threats

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

3.6.2.2.8 Nassau Grouper (*Epinephelus striatus*)

3.6.2.2.8.1 Status and Management

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

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

3.6.2.2.8.2 Habitat and Geographic Range

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

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

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

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

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

3.6.2.2.8.3 Population Trends

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

3.6.2.2.8.4 Predator and Prey Interactions

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

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

3.6.2.2.8.5 Species-Specific Threats

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

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

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

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

3.6.2.2.9 Oceanic Whitetip Shark (*Carcharhinus longimanus*)

3.6.2.2.9.1 Status and Management

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

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

3.6.2.2.9.2 Habitat and Geographic Range

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

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

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

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

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

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

3.6.2.2.9.3 Population Trends

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

3.6.2.2.9.4 Predator and Prey Interactions

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

3.6.2.2.9.5 Species-Specific Threats

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

3.6.2.2.10 Scalloped Hammerhead Shark (*Sphyrna lewini*)

3.6.2.2.10.1 Status and Management

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

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

3.6.2.2.10.2 Habitat and Geographic Range

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

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

3.6.2.2.10.3 Population Trends

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

3.6.2.2.10.4 Predator and Prey Interactions

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

3.6.2.2.10.5 Species-Specific Threats

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

3.6.2.2.11 Alewife (*Alosa pseudoharengus*)

3.6.2.2.11.1 Status and Management

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

3.6.2.2.11.2 Habitat and Geographic Range

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

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

3.6.2.2.11.3 Population Trends

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

3.6.2.2.11.4 Predator and Prey Interactions

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

3.6.2.2.11.5 Species-Specific Threats

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

3.6.2.2.12 Blueback Herring (*Alosa aestivalis*)

3.6.2.2.12.1 Status and Management

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

3.6.2.2.12.2 Habitat and Geographic Range

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

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

3.6.2.2.12.3 Population Trends

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

3.6.2.2.12.4 Predator and Prey Interactions

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

3.6.2.2.12.5 Species-Specific Threats

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

3.6.2.2.13 Cusk (*Brosme brosme*)

3.6.2.2.13.1 Status and Management

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

3.6.2.2.13.2 Habitat and Geographic Range

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

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

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

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

3.6.2.2.13.3 Population Trends

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

3.6.2.2.13.4 Predator and Prey Interactions

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

3.6.2.2.13.5 Species-Specific Threats

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

3.6.2.2.14 Dwarf Seahorse (*Hippocampus zosterae*)

3.6.2.2.14.1 Status and Management

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

3.6.2.2.14.2 Habitat and Geographic Range

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

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

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

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

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

3.6.2.2.14.3 Population Trends

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

3.6.2.2.14.4 Predator and Prey Interactions

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

3.6.2.2.14.5 Species-Specific Threats

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

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

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

3.6.2.3 Species Not Listed under the Endangered Species Act

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Note: N/A = not applicable

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.6.2.3.5 Ratfishes (Order Chimaeriformes)

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

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

3.6.2.3.6 Sturgeons (Order Acipenseriformes)

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

3.6.2.3.7 Gars (Order Lepisosteiformes)

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

3.6.2.3.8 Herrings (Order Clupeiformes)

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

3.6.2.3.9 Tarpons (Orders Elopiformes and Albuliformes)

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

3.6.2.3.10 Eels (Orders Anguilliforms, Notacanthiformes, and Saccopharyngiformes)

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

3.6.2.3.11 Salmonids (Order Salmoniformes)

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

3.6.2.3.12 Argentines and Allies (Order Argentiniformes)

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

3.6.2.3.13 Catfishes (Order Siluriformes)

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

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

3.6.2.3.14 Bristlemouths and Allies (Order Stomiiformes)

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

3.6.2.3.15 Greeneyes and Allies (Order Aulopiformes)

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

3.6.2.3.16 Lanternfishes and Allies (Order Myctophiformes)

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

3.6.2.3.17 Hakes and Allies (Order Gadiformes).

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

3.6.2.3.18 Brotulas and Allies (Order Ophidiiformes)

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

3.6.2.3.19 Toadfishes and Allies (Order Batrachoidiformes)

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

3.6.2.3.20 Anglerfishes and Allies (Order Lophiiformes)

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

3.6.2.3.21 Flying Fishes (Order Beloniformes)

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

3.6.2.3.22 Killifishes (Order Cyprinodontiformes)

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

3.6.2.3.23 Silversides (Order Atheriniformes).

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

3.6.2.3.24 Opahs and Allies (Order Lampriformes)

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

3.6.2.3.25 Squirrelfishes and Allies (Order Beryciformes)

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

3.6.2.3.26 Dories and Allies (Order Zeiformes)

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

3.6.2.3.27 Pipefishes and Allies (Order Syngnathiformes)

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

3.6.2.3.28 Sticklebacks (Order Gasterosteiformes)

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

3.6.2.3.29 Scorpionfishes (Order Scorpaeniformes)

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

3.6.2.3.30 Mullets (Order Mugiliformes)

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

3.6.2.3.31 Order Perciformes

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

3.6.2.3.31.1 Perches and Allies

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

3.6.2.3.31.2 Wrasses and Allies

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

3.6.2.3.31.3 Eelpouts and Allies

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

3.6.2.3.31.4 Stargazers

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

3.6.2.3.31.5 Blennies, Gobies, and Allies

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

3.6.2.3.31.6 Surgeonfishes

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

3.6.2.3.31.7 Tunas and Allies

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

3.6.2.3.31.8 Butterfishes

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

3.6.2.3.32 Flatfishes (Order Pleuronectiformes)

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

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

3.6.2.3.33 Pufferfishes (Order Tetraodontiformes)

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

3.6.3 Environmental Consequences

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

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

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

3.6.3.1 Acoustic Stressors

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

3.6.3.1.1 Background

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

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

3.6.3.1.1.1 Injury

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

Injury due to Impulsive Sound Sources

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

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

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

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

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

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

Injury due to Sonar and Other Transducers

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

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

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

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

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

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

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

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

3.6.3.1.1.2 Hearing Loss

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

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

Hearing Loss due to Impulsive Sound Sources

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

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

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

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

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

Hearing Loss due to Sonar and Other Transducers

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

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

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

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

Hearing Loss due to Vessel Noise

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

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

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

3.6.3.1.1.3 Masking

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

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

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

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

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

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

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

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

3.6.3.1.1.4 Physiological Stress

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

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

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

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

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

3.6.3.1.1.5 Behavioral Reactions

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

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

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

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

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

Behavioral Reactions due to Impulsive Sound Sources

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

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

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

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

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

Behavioral Reactions due to Sonar and Other Transducers

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

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

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

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

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

Behavioral Reactions due to Vessel Noise

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

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

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

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

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

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

3.6.3.1.1.6 Long-Term Consequences

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

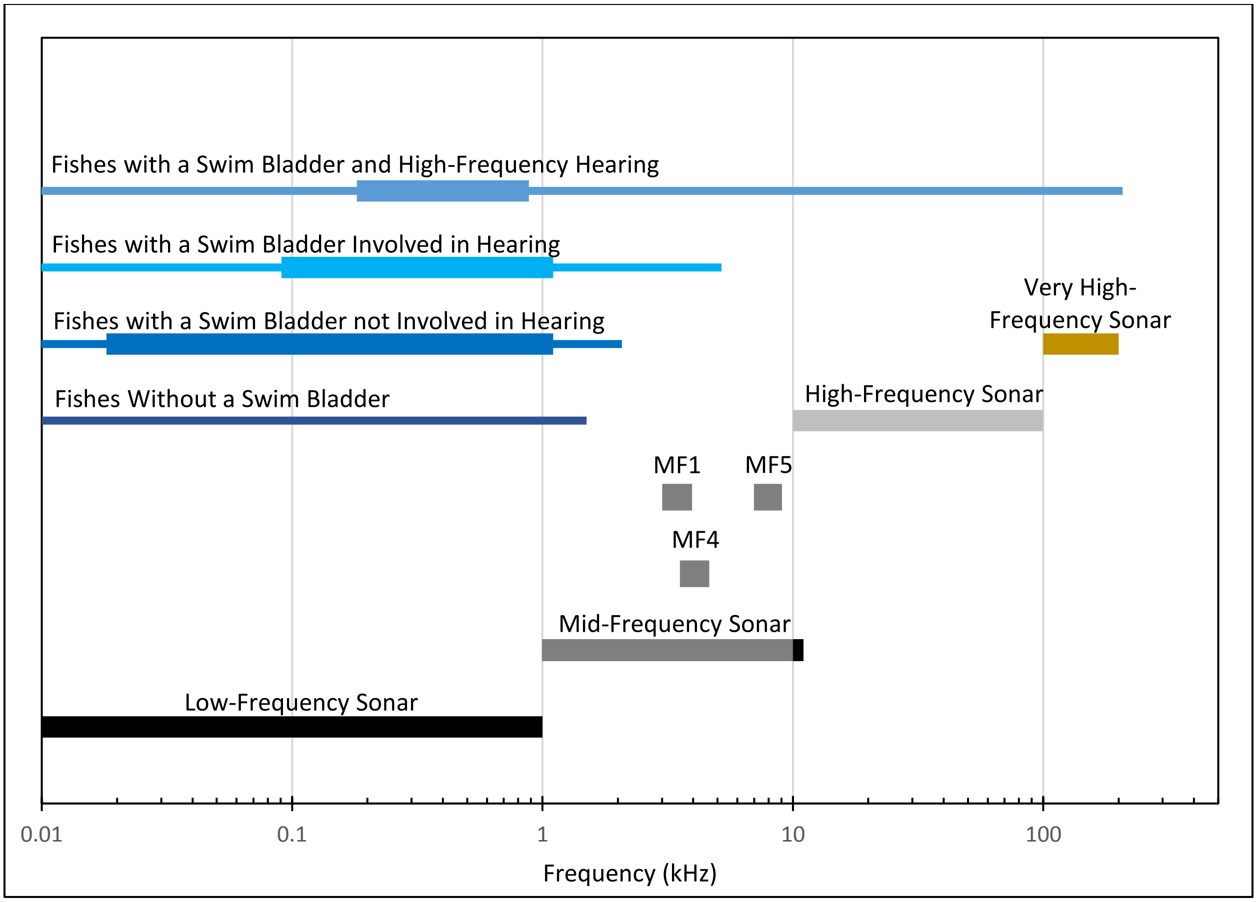
3.6.3.1.2 Impacts from Sonar and Other Transducers

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

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

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

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



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

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

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

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

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

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

3.6.3.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

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

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

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

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

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

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

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

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

3.6.3.1.2.2 Impact Ranges from Sonar and Other Transducers

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

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

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

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

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

3.6.3.1.2.3 Impacts from Sonar and Other Transducers under Alternative 1

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.6.3.1.2.4 Impacts from Sonar and Other Transducers under Alternative 2

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

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

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

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

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

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

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

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

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

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

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

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

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

3.6.3.1.3 Impacts from Air Guns

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

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

3.6.3.1.3.1 Methods for Analyzing Impacts for Air Guns

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

Criteria and Thresholds Used to Estimate Impacts from Air Guns

Mortality and Injury from Air Guns

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

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

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

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

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

Hearing Loss from Air Guns

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

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

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

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

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

<u>Impact Ranges for Air Guns</u>

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

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

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

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

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

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

3.6.3.1.3.2 Impacts from Air Guns under Alternative 1

Impacts from Air Guns under Alternative 1 for Training Activities

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

Impacts from Air Guns under Alternative 1 for Testing Activities

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

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

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

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

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

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

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

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

3.6.3.1.3.3 Impacts from Air Guns under Alternative 2

Impacts from Air Guns under Alternative 2 for Training Activities

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

Impacts from Air Guns under Alternative 2 for Testing Activities

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

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

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

3.6.3.1.3.4 Impacts from Air Guns under the No Action Alternative

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

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

3.6.3.1.4 Impacts from Pile Driving

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

3.6.3.1.4.1 Methods for Analyzing Impact from Pile Driving

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

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

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

Mortality and Injury from Pile Driving

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

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

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

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

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

Hearing Loss from Pile Driving

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

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

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

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

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

Modeling of Pile Driving Noise

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

3.6.3.1.4.2 Impact Ranges for Pile Driving

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

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

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

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

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

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

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

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

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

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

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

3.6.3.1.4.3 Impacts from Pile Driving under Alternative 1

Impacts from Pile Driving under Alternative 1 for Training Activities

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

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

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

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

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

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

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

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

Impacts from Pile Driving under Alternative 1 for Testing Activities

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

3.6.3.1.4.4 Impacts from Pile Driving under Alternative 2

Impacts from Pile Driving under Alternative 2 for Training Activities

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

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

Impacts from Pile Driving under Alternative 2 for Testing Activities

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

3.6.3.1.4.5 Impacts from Pile Driving under the No Action Alternative

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

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

3.6.3.1.5 Impacts from Vessel Noise

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

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

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

3.6.3.1.5.1 Methods for Analyzing Impacts from Vessel Noise

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

3.6.3.1.5.2 Impacts from Vessel Noise under Alternative 1

Impacts from Vessel Noise under Alternative 1 for Training Activities

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

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

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

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

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

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

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

Impacts from Vessel Noise under Alternative 1 for Testing Activities

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

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

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

3.6.3.1.5.3 Impacts from Vessel Noise under Alternative 2

Impacts from Vessel Noise under Alternative 2 for Training Activities

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

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

Impacts from Vessel Noise under Alternative 2 for Testing Activities

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

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

3.6.3.1.5.4 Impacts from Vessel Noise under the No Action Alternative

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

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

3.6.3.1.6 Impacts from Aircraft Noise

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

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

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

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

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

3.6.3.1.6.1 Methods for Analyzing Impacts from Aircraft Noise

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

3.6.3.1.6.2 Impacts from Aircraft Noise under Alternative 1

Impacts from Aircraft Noise under Alternative 1 for Training Activities

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

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

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

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

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

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

Impacts from Aircraft Noise under Alternative 1 for Testing Activities

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

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

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

3.6.3.1.6.3 Impacts from Aircraft Noise under Alternative 2

Impacts from Aircraft Noise under Alternative 2 for Training Activities

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

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

Impacts from Aircraft Noise under Alternative 2 for Testing Activities

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

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

3.6.3.1.6.4 Impacts from Aircraft Noise under the No Action Alternative

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

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

3.6.3.1.7 Impacts from Weapons Noise

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

3.6.3.1.7.1 Methods for Analyzing Impacts from Weapons Noise

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

3.6.3.1.7.2 Impacts from Weapons Noise under Alternative 1

Impacts from Weapons Noise under Alternative 1 for Training Activities

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

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

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

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

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

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

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

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

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

Impacts from Weapons Noise under Alternative 1 for Testing Activities

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

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

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

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

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

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

3.6.3.1.7.3 Impacts from Weapons Noise under Alternative 2

Impacts from Weapons Noise under Alternative 2 for Training Activities

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

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

Impacts from Weapons Noise under Alternative 2 for Testing Activities

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

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

3.6.3.1.7.4 Impacts from Weapons Noise under the No Action Alternative

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

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

3.6.3.2 Explosive Stressors

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

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

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

3.6.3.2.1 Background

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

3.6.3.2.1.1 Injury

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

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

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

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

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

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

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

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

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

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

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

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

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

3.6.3.2.1.2 Hearing Loss

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

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

3.6.3.2.1.3 Masking

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

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

3.6.3.2.1.4 Physiological Stress

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

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

3.6.3.2.1.5 Behavioral Reactions

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

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

3.6.3.2.1.6 Long-term Consequences

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

3.6.3.2.2 Impacts from Explosives

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

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

3.6.3.2.2.1 Methods for Analyzing Impacts from Explosives

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

Criteria and Thresholds used to Estimate Impacts on Fishes from Explosives

Mortality and Injury from Explosives

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

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

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

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

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

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

SPL_{peak} = Peak sound pressure level.

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

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

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

Hearing Loss from Explosives

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

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

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

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

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

3.6.3.2.2.2 Impact Ranges for Explosives

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

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

3.6.3.2.2.3 Impacts from Explosives under Alternative 1

Impacts from Explosives under Alternative 1 for Training Activities

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Impacts from Explosives under Alternative 1 for Testing Activities

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

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

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

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

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

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

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

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

3.6.3.2.2.4 Impacts from Explosives under Alternative 2

Impacts from Explosives under Alternative 2 for Training Activities

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

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

Impacts from Explosives under Alternative 2 for Testing Activities

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

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

3.6.3.2.2.5 Impacts from Explosives under the No Action Alternative

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

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

3.6.3.3 Energy Stressors

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

3.6.3.3.1 Impacts from In-Water Electromagnetic Devices

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

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

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

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

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

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

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

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

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

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

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

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

3.6.3.3.1.1 Impacts from In-Water Electromagnetic Devices under Alternative 1

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

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

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

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

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

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

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

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

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

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

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

Under Alternative 1, testing activities involving in-water electromagnetic devices occur in a number of areas, including Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Gulf of Mexico Range Complex, South Florida Ocean Measurement Facility, Naval Surface Warfare Center Panama City Testing Range, and within inshore waters (see Table 3.0-14 and Table 3.0-15). Atlantic salmon and scalloped hammerhead sharks belonging to the Central and Southwest Atlantic Distinct Population Segment do not occur within these specified areas and would not be exposed to in-water electromagnetic devices during testing activities.

ESA-listed species that occur within these areas, including Atlantic sturgeon, shortnose sturgeon smalltooth sawfish, Gulf sturgeon, Nassau grouper, scalloped hammerhead sharks, oceanic whitetip sharks, and giant manta rays would have the potential to be exposed to in-water electromagnetic devices.

Exposure is limited to those marine fish groups able to detect electromagnetic properties in the water column, as described in Section 3.6.2 (Affected Environment), such as elasmobranchs, sturgeon, tuna, salmon, eels, and stargazers (Bullock et al., 1983; Helfman et al., 2009). Two such species, the Atlantic torpedo ray (*Torpedo nobiliana*) and the lesser electric ray (*Narcine brasiliensis*) occur in the Naval

Surface Warfare Center, Panama City Division Testing Range, where a portion of the electromagnetic activities would be concentrated.

All of the ESA-listed fish species occurring in areas where testing occurs are capable of detecting electromagnetic energy, with the exception of Nassau grouper. Potential exposure to electromagnetic testing activities may occur in the offshore portions of the testing ranges that lie within the continental shelf, overlapping the normal distribution of Gulf sturgeon, Atlantic sturgeon, shortnose sturgeon, and smalltooth sawfish. Oceanic whitetip sharks and giant manta rays are found in offshore waters and may encounter in-water electromagnetic devices used in testing activities in those areas. Behavioral changes are not expected to have lasting effects on the survival, growth, recruitment, or reproduction of fish species.

Testing activities involving in-water electromagnetic devices may overlap with Gulf sturgeon critical habitat in the coastal waters of the Panama City OPAREA. However, the biological and physical features associated with the critical habitat designations would not be impacted by these activities. The use of electromagnetic devices during testing activities does not overlap with designated Atlantic sturgeon critical habitat.

All of critical habitat biological and physical features required by Atlantic salmon are applicable to freshwater only and are outside the Study Area. Therefore, none of the electromagnetic stressors would affect Atlantic salmon critical habitat. The biological and physical features for smalltooth sawfish are red mangrove habitats and shallow marine waters of less than 1 m deep. Electromagnetic activities do not occur at these depths and thus would not overlap with smalltooth sawfish critical habitat.

The in-water electromagnetic devices used in testing activities would not cause any risk to fish because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) highly localized potential impact area, and (3) limited and temporally distinct duration of the activities (hours). Fishes may have a detectable response to electromagnetic exposure, but would likely recover completely. Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of in-water electromagnetic devices during testing activities, as described under Alternative 1, would have no effect on Atlantic salmon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Testing activities under Alternative 1 involving the use of in-water electromagnetic devices may affect Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.3.1.2 Impacts from In-Water Electromagnetic Devices under Alternative 2

Impacts from In-Water Electromagnetic Devices under Alternative 2 for Training Activities

Because the locations, number of events, and potential effects associated with in-water electromagnetic devices would be the same under Alternatives 1 and 2, impacts experienced by fishes from in-water electromagnetic devices use under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of in-water electromagnetic devices during training activities, as described under Alternative 2, would have no effect on Atlantic salmon, Nassau grouper, and the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, and critical habitats designated for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Training activities under Alternative 2 involving the use of in-water electromagnetic devices may affect Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from In-Water Electromagnetic Devices under Alternative 2 for Testing Activities

Because the locations, number of events, and potential effects associated with in-water electromagnetic devices would be the same under Alternatives 1 and 2, impacts experienced by fishes from in-water electromagnetic devices use under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of in-water electromagnetic devices during testing activities, as described under Alternative 2, would have no effect on Atlantic salmon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Testing activities under Alternative 2 involving the use of in-water electromagnetic devices may affect Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.3.1.3 Impacts from In-Water Electromagnetic Devices under the No Action Alternative

Impacts from In-Water Electromagnetic Devices under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Electromagnetic fields from towed devices or unmanned mine warfare systems would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.3.2 Impacts from In-Air Electromagnetic Devices

In-air electromagnetic stressors are not applicable to fishes because they are transmitted in the air and not underwater and will not be analyzed further in this section.

3.6.3.3.3 Impacts from High-Energy Lasers

This section analyzes the potential impacts of high energy lasers on fishes. As discussed in Section 3.0.3.3.3.3 (Lasers), high energy laser weapons are designed to disable surface targets, rendering them immobile. The primary impact from high-energy lasers would be from the laser beam striking the fish at or near the water's surface, which could result in injury or death.

Fish could be exposed to a laser only if the beam missed the target. Should the laser strike the sea surface, individual fish at or near the surface could be exposed. The potential for exposure to a high energy laser beam decreases as the water depth increases. Most fish are unlikely to be exposed to laser activities because they primarily occur more than a few meters below the sea surface.

3.6.3.3.3.1 Impacts from High-Energy Lasers under Alternative 1

Impacts from High-Energy Lasers under Alternative 1 for Training Activities

Under Alternative 1, training activities involving high-energy lasers only occur within the Virginia Capes and Jacksonville Range Complexes. Fish species in these areas that occur near the surface, such as oceanic whitetip sharks and giant manta rays, would have the potential to be exposed to high-energy lasers. Although occurring in areas of laser use, while in coastal and offshore waters, Atlantic sturgeon, shortnose sturgeon, and smalltooth sawfish typically occur in the lower depths of the water column or near the seafloor and would not be exposed. Atlantic salmon, Gulf sturgeon, Nassau grouper, and the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark do not occur in areas of laser use. In addition, the use of high energy lasers under Alternative 1 for training activities does not overlap with the designated critical habitat for any of the ESA-listed fish species.

Pursuant to the ESA, the use of high-energy lasers during training activities, as described under Alternative 1, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during training activities under Alternative 1 may affect giant manta rays and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from High-Energy Lasers under Alternative 1 for Testing Activities

Under Alternative 1, high-energy laser weapons would be used for testing activities in the AFTT Study Area, the Northeast U.S. Continental Shelf and Southeast U.S. Continental Shelf Large Marine Ecosystems and Gulf Stream Open Ocean Area (see Table 3.0-16). High-energy laser testing occurs at the highest frequency within the Virginia Capes Range Complex, but would also occur at the Northeast Range Complexes, Navy Cherry Point Range Complex, Jacksonville Range Complex, Key West Range Complex, Gulf of Mexico Range Complex, Naval Undersea Warfare Center Newport Testing Range, South Florida Ocean Measurement Facility, and Naval Surface Warfare Center Panama City Testing Range. Species that occur near the surface at these locations within these areas would have the potential to be exposed.

Some ESA-listed species such as Atlantic salmon, oceanic whitetip sharks, giant manta rays, and Central and Southwestern Atlantic Distinct Population Segment scalloped hammerhead sharks that are found in offshore locations and occur near the surface of the water column, may pose a higher risk of being exposed to high-energy lasers. Although occurring in areas of laser use, while in coastal and offshore waters, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, smalltooth sawfish, and Nassau grouper typically occur in the lower depths of the water column or near the seafloor and would not be exposed. High-energy laser weapons tests would not overlap with critical habitat for Atlantic salmon, Atlantic sturgeon, smalltooth sawfish, or Gulf sturgeon

Fishes are unlikely to be exposed to high-energy lasers based on: (1) the relatively low number of events, (2) the very localized potential impact area of the laser beam, and (3) the temporary duration of potential impact (seconds).

Pursuant to the ESA, the use of high-energy lasers during testing activities, as described under Alternative 1, would have no effect on Atlantic sturgeon, Gulf sturgeon, Nassau grouper, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during testing activities under Alternative 1 may affect Atlantic salmon, giant manta rays, oceanic whitetip sharks, and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.3.3.2 Impacts from High-Energy Lasers under Alternative 2

Impacts from High-Energy Lasers under Alternative 2 for Training Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, impacts experienced by fishes from high-energy laser use under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of high-energy lasers during training activities, as described under Alternative 2, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during training activities under Alternative 2 may affect giant manta rays and oceanic whitetip sharks.

Impacts from High-Energy Lasers under Alternative 2 for Testing Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, impacts experienced by fishes from high-energy laser use under Alternative 2 are the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of high-energy lasers during testing activities, as described under Alternative 2, would have no effect on Atlantic sturgeon, Gulf sturgeon, Nassau grouper, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during testing activities under Alternative 2 may affect Atlantic salmon, giant manta rays, oceanic whitetip sharks, and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks.

3.6.3.3.3.3 Impacts from High-Energy Lasers under the No Action Alternative

Impacts from High-Energy Lasers under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area and fishes would not be exposed to high-energy lasers. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and potential for strike during training and testing activities within the Study Area from (1) vessels and in water devices, (2) military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions, and (3) seafloor devices. A discussion of the relative magnitude and location of physical disturbance and strike stressors is presented in Section 3.0.3.3.4 (Physical Disturbance and

Strike Stressors), while Table B-1 and Table B-2 (Appendix B, Activity Stressor Matrices) list the activities that use the devices.

How a physical strike impacts a fish depends on the relative size of the object potentially striking the fish and the location of the fish in the water column. Before being struck by an object, Atlantic salmon for example, would sense a pressure wave through the water (Hawkins & Johnstone, 1978) and have the ability to swim away from the oncoming object. The movement generated by a large object moving through the water would simply displace small fishes in open water, such as Atlantic herring. Some fish might have time to detect the approaching object and swim away; others could be struck before they become aware of the object. An open-ocean fish that is displaced a small distance by movements from an object falling into the water nearby would likely continue on its original path as if nothing had happened. However, a bottom-dwelling fish near a sinking object would likely be disturbed, and may exhibit a general stress response, as described in Section 3.0.3.6 (Biological Resource Methods). As in all vertebrates, the function of the stress response in fish is to rapidly alter blood chemistry levels or ratios to prepare the fish to flee or fight (Helfman et al., 2009). This generally adaptive physiological response can become a liability to the fish if the stressor persists and the fish is not able to return to its baseline physiological state. When stressors are chronic, the fish may experience reduced growth, health, or survival (Wedemeyer et al., 1990). If the object hits the fish, direct injury (in addition to stress) or death may result.

The potential responses to a physical strike are varied, but include behavioral changes such as avoidance, altered swimming speed and direction, physiological stress, and physical injury or mortality. Despite their ability to detect approaching vessels using a combination of sensory cues (e.g., sight, hearing, and lateral line), larger slow-moving fishes (e.g., whale sharks [*Rhincodon typus*], basking sharks [*Cetorhinus maximus*], manta rays [*Manta* spp.), sturgeon [*Acipenser* spp.], and ocean sunfish) cannot avoid all collisions, with some collisions resulting in mortality (Balazik et al., 2012; Braun et al., 2015; Brown & Murphy, 2010; Couturier et al., 2012; Deakos et al., 2011; Foderaro, 2015; Germanov & Marshall, 2014; Graham et al., 2012; Miller & Klimovich, 2016; Ramirez-Macias et al., 2012; Rowat et al., 2007; Speed et al., 2008; Stevens, 2007). Many fishes respond by darting quickly away from the stimulus. Some other species may respond by freezing in place and adopting cryptic coloration, while still some other species may respond in an unpredictable manner. Regardless of the response, the individual must stop its current activity and divert its physiological and cognitive attention to responding to the stressor (Helfman et al., 2009). The energy costs of reacting to a stressor depend on the specific situation, but in all cases the caloric requirements of stress reactions reduce the amount of energy available to the fish for other functions, such as predator avoidance, reproduction, growth, and maintenance (Wedemeyer et al., 1990).

The ability of a fish to return to its previous activity following a physical strike (or near-miss resulting in a stress response) is a function of a variety of factors. Some fish species are more tolerant of stressors than others and become re-acclimated more easily. Within a species, the rate at which an individual recovers from a physical strike may be influenced by its age, sex, reproductive state, and general condition. A fish that has reacted to a sudden disturbance by swimming at burst speed would tire after only a few minutes; its blood hormone and sugar levels (cortisol and glucose) may not return to normal for up to, or longer than, 24 hours. During its recovery period, the fish would not be able to attain burst speeds and would be more vulnerable to predators (Wardle, 1986). If the individual were not able to regain a steady state following exposure to a physical stressor, it may suffer reduced immune function and even death (Wedemeyer et al., 1990).

Potential impacts of physical disturbance and strike to adults may be different than for other life stages (e.g., eggs, larvae, juveniles) because these life stages do not necessarily occur together in the same location (Botsford et al., 2009; Sabates et al., 2007), and because they have different response capabilities. The numbers of eggs and larvae exposed to vessel movements would be low relative to total ichthyoplankton biomass (Able & Fahay, 1998); therefore, measurable effects on fish recruitment would not be expected. Also, the early life stages of most marine fishes (excluding sharks and other livebearers) already have extremely high natural mortality rates (10 to 85 percent per day) from predation on these life stages (Helfman et al., 2009), and therefore, most eggs and larvae are not expected to survive to the next life stage.

3.6.3.4.1 Impacts from Vessels and In-Water Devices

Representative Navy vessel types, lengths, and speeds of vessels and in-water devices used in the Study Area is presented in Table 3.0-17 and Table 3.0-21. The number and location of activities, including vessels and in-water devices for each alternative is presented in Table 3.0-18 and Table 3.0-22, while Table B-1 (Appendix B, Activity Stressor Matrices) lists the activities that use the devices.

Vessels

Vessels do not normally collide with adult fishes, most of which can detect and avoid them. One study on Barents sea capelin (*Mallotus villosus*) behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al., 2004), reducing the potential for vessel strikes. Misund (1997) found that fishes, such as Polar cod (*Boreogadus saida*), haddock (*Melanogrammus aeglefinus*), jack mackerel (*Trachurus symmetricus*), sardine (*Sardina pilchardus*), herring, anchovy (*Engraulis ringens*), and capelin, that were ahead of a ship showed avoidance reactions and did so at ranges of 50 to 350 m. When the vessel passed over them, some fishes had sudden avoidance responses that included lateral avoidance or downward compression of the school. Conversely, Rostad et al. (2006) observed that some fishes are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations. Fishes involved in that study included herring (*Clupea harengus*), sprat (*Sprattus sprattus*), and whitefish (*Merlangius merlangus*) (Rostad et al., 2006). Fish behavior in the vicinity of a vessel is therefore quite variable, depending on the type of fish, its life history stage, behavior, time of day, and the sound propagation characteristics of the water (Schwarz & Greer, 1984). Early life stages of most fishes could be displaced by vessels and not struck in the same manner as adults of larger species. However, a vessel's propeller movement or propeller wash could entrain early life stages. The low-frequency sounds of large vessels or accelerating small vessels caused avoidance responses among herring (Chapman & Hawkins, 1973), but avoidance ended within 10 seconds after the vessel departed.

There are a few notable exceptions to this assessment of potential vessel strike impacts on fish groups. Large slow-moving fishes such as whale sharks (Ramirez-Macias et al., 2012; Rowat et al., 2007; Speed et al., 2008; Stevens, 2007), basking sharks (Pacific Shark Research Center, 2017; The Shark Trust, 2017), manta rays (Braun et al., 2015; Couturier et al., 2012; Deakos et al., 2011; Germanov & Marshall, 2014; Graham et al., 2012; Miller & Klimovich, 2016), and sturgeon (Balazik et al., 2012; Brown & Murphy, 2010; Foderaro, 2015) may occur near the surface in open-ocean and coastal areas, thus making them more susceptible to ship strikes which may result in blunt trauma, lacerations, fin damage, or mortality. Stevens (2007) noted that increases in the numbers and sizes of shipping vessels in the modern cargo fleets make it difficult to gather strike-related mortality data for whale sharks because personnel on large ships are often unaware of collisions; therefore, the occurrence of vessel strikes is likely much higher than has been documented by the few studies that have been conducted. This holds true not just for whale sharks, but also for any of the aforementioned fish species.

In addition to whale sharks, Atlantic sturgeon have also been documented to be susceptible to vessel strikes. Brown and Murphy (2010) found that 28 deaths of Atlantic sturgeon in the Delaware Bay and the Delaware River were reported over the four-year period of 2005 to 2008. Of those, 50 percent were caused by vessel collisions, although the size and type of the vessels was unknown. An unknown number of additional sturgeon were likely struck by vessels and were not included in this total. Based on an egg-per-recruit analysis of the Delaware River population, the authors concluded that an annual mortality rate of 2.5 percent of the females could have adverse impacts on the population (Brown & Murphy, 2010). In Virginia, Balazik et al. (2012) investigated Atlantic sturgeon mortalities due to vessel strikes that occurred in upstream areas of the James River. Based on observations of fish implanted with acoustic transmitters, the authors concluded that when moving the tracked individuals occurred in water depths overlapping with the draft of ocean cargo vessels (about 23 ft.), but were rarely in depths overlapping the draft of tugboats and small recreational craft (about 3 to 7 ft.). However, as a result of the very small sample size (three fish), this conclusion bears little support. The fish were detected in the navigation channel of the river 69 percent of the time. More recently in New York, it was noted that over the latest three-year period (2012 through 2014), there were 76 known Atlantic sturgeon fatalities attributed to boat strikes around the Tappan Zee Bridge on the Hudson River, in addition to over two dozen more reported during the first six months of 2015 (Foderaro, 2015). This reflects a significant increase when compared to the previous three-year period (2009 through 2011) during which only six sturgeon fatalities were documented. Many have attributed this increase in sturgeon mortality to the increased boat traffic associated with the expansion of the Tappan Zee Bridge, which began in 2012. However, they may also, in part, be the result of an increased effort into monitoring for fish strandings. Regardless, it illustrates the level of susceptibility of Atlantic sturgeon to vessel strikes.

Based on the typical physiological responses described in Section 3.6.3.4 (Physical Disturbance and Strike Stressors), vessel movements are not expected to compromise the general health or condition of individual fishes, except for large slow-moving fishes such as whale sharks, basking sharks, manta rays, sturgeon, and ocean sunfish (Balazik et al., 2012; Brown & Murphy, 2010; Foderaro, 2015; Rowat et al., 2007; Speed et al., 2008; Stevens, 2007).

In-Water Devices

In-water devices do not normally collide with adult fishes, as most can detect and avoid them. Fish responses to in-water devices would be similar to those discussed above for vessels. Fishes would likely show varying behavioral avoidance responses to in-water devices. Early life stages of most fishes could be displaced by in-water devices and not struck in the same manner as adults of larger species. Because in-water devices are continuously moving, most fishes are expected to move away from it or to follow behind it.

3.6.3.4.1.1 Impacts from Vessels and In-Water Devices under Alternative 1

Impacts from Vessels and In-Water Devices under Alternative 1 for Training Activities

Section 3.0.3.3.4.1 (Vessels and In-Water Devices) provide estimates of relative vessel and in-water devices use and location for each of the alternatives. These estimates are based on the number of activities predicted for each alternative. While these estimates predict use, actual Navy vessel usage depends on military training and testing requirements, deployment schedules, annual budgets, and other unpredictable factors. Training concentrations mostly depend on locations of Navy shore installations and established training areas. The Navy's use of these areas has not appreciably changed in the last decade and are not expected to change in the foreseeable future. Under Alternative 1, the concentration of vessel movement and in-water device use and the manner in which the Navy trains would remain consistent with the range of variability observed over the last decade. As underwater technologies advance, it is likely that the frequency of in-water device use may increase. However, the Navy does not foresee any appreciable changes in the locations where in-water devices have been used over the last decade, and therefore the level at which strikes are expected to occur is likely to remain consistent with the previous decade.

Navy training vessel traffic could occur anywhere in the Study Area, but would especially be concentrated in Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, as presented in Table 3.0-18. In addition, there are numerous areas within inshore waters where vessels during training activities would be concentrated, including the Lower Chesapeake Bay; James River and tributaries; Norfolk, VA; Mayport, FL; Groton, CT; and Narragansett, RI (see Table 3.0-19). Of particular importance would be inshore areas where activities involving large amounts of high-speed vessel movements occur, such as the Lower Chesapeake Bay; James River and tributaries; York River; Cooper River, SC; and Narragansett, RI (see Table 3.0-20). Navy training in-water device use could also take place anywhere in the Study Area, but primarily occurs in the Virginia Capes, Jacksonville, and Navy Cherry Point Range Complexes. A large number of activities involving in-water devices also occur in inshore waters, predominately in the Lower Chesapeake Bay; James River and tributaries; Mayport, FL; and Kings Bay, GA (see Table 3.0-23).

The risk of a strike from vessels and in-water devices such as a remotely operated vehicles, unmanned surface vehicles, unmanned underwater vehicles, motorized autonomous targets, or towed mine warfare devices used in training activities would be extremely low because (1) most fishes can detect and avoid vessel and in-water device movements; and (2) the types of fish that are likely to be exposed to vessel and in-water device strike are limited and occur in low concentrations where vessels and in-water devices are most frequently used. Potential impacts from exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

As described above, the potential exception would be large, slow-moving fish species, such as Atlantic sturgeon, which are documented to be highly susceptible to vessel strikes and are concentrated in inshore areas where intense high speed vessel movement activities as part of the Proposed Action are common (see Table 3.0-20). Atlantic sturgeon may be susceptible to vessel strikes in these areas, including Lower Chesapeake Bay, James River and tributaries, York River, and Cooper River, resulting in potential injury or mortality. This species is most susceptible to vessel and in-water device strikes in these areas because all five distinct population segments congregate in large numbers in the lower Chesapeake Bay, all sturgeon belonging to two separate and genetically distinct spawning populations from the James River and the York River populations must pass through the Lower Chesapeake Bay on their way to and from their spawning grounds, and the York River spawning population is estimated to be very small (several hundred fish) and likely consists of higher numbers of males and relatively few females. As a result, even a loss of a couple of females to this spawning population could have long-term consequences. Gulf sturgeon, a congener of Atlantic sturgeon, are also likely susceptible to vessel and in-water device strikes.

Due to their preference for riverine habitats, absence from the Lower Chesapeake Bay and its tributaries, and close association to the seafloor, shortnose sturgeon are not considered to be highly susceptible to vessel and in-water device strikes, with only a few ship strike have been documented for this species (Shortnose Sturgeon Status Review Team, 2010). Likewise, smalltooth sawfish are typically found in shallow, coastal waters where training activities do not occur. When in deeper waters, smalltooth sawfish tend to remain along the seafloor. Nassau grouper are strongly associated with reef and live hard bottom seafloor habitats and, as such, would not be susceptible to vessel and in-water device use.

Giant manta rays in offshore areas may be susceptible to vessel strikes in those areas, as are the closely related reef manta ray (Braun et al., 2015; Couturier et al., 2012; Deakos et al., 2011; Germanov & Marshall, 2014; Graham et al., 2012; Miller & Klimovich, 2016). However, unlike the reef manta ray, the giant manta ray is typically found in low numbers and rarely aggregates.

As Atlantic salmon, scalloped hammerhead sharks, and oceanic whitetip sharks also typically occur within the upper water column or at the surface, there is the potential for an interaction to occur, though it is highly unlikely given their ability to detect and avoid vessel and in-water device movements.

Vessel and in-water device use during training activities potentially overlaps with designated critical habitat for Atlantic salmon, Gulf sturgeon, smalltooth sawfish and Atlantic sturgeon, but vessel and in-water device use would not impact any of the physical and biological features associated with critical habitat designations.

Pursuant to the ESA, the use of vessels and in-water devices during training activities, as described under Alternative 1, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Vessels and In-Water Devices under Alternative 1 for Testing Activities

As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), most of the testing activities involve vessel movements. However, the number of activities that include the vessel movement for testing is comparatively lower than the number of training activities. In addition, testing often occurs jointly with a training event, so it is likely that the testing activity would be conducted from a training vessel. Vessel movement in conjunction with testing activities could be widely dispersed throughout the Study Area, but would be concentrated near naval ports, piers, range complexes, and testing ranges. Specifically, testing activities that include vessels would be conducted within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes; the Naval Undersea Warfare Division, Newport Testing Range; South Florida Ocean Measurement Facility Testing Range; Naval Surface Warfare Center, Panama City Division Testing Range; as well as inshore waters within the AFTT Study Area. Testing activities involving the use of in-water devices would also occur in the AFTT Study Area at any time of year. Under Alternative 1, testing activities involving the use of in-water devices would be conducted throughout the AFTT Study Area, including the same areas where vessel movement is occurring (with the exception of inshore waters locations).

As previously discussed, with the exception of some large, slow-moving species that may occur at the surface, the risk of a strike from a vessel or in-water device used in testing activities would be extremely low because most fishes can detect and avoid in-water device movements, and exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

As described above in the Alternative 1 training analysis, Atlantic sturgeon, Gulf sturgeon, and giant manta rays have been shown to be susceptible to vessel strikes. As Atlantic salmon, scalloped hammerhead sharks, and oceanic whitetip sharks also typically occur within the upper water column or at the surface, there is the potential for an interaction to occur, though it is highly unlikely given their ability to detect and avoid vessel and in-water device movements.

Due to their preference for riverine habitats, absence from the Lower Chesapeake Bay and its tributaries, and close association to the seafloor, shortnose sturgeon are susceptible to vessel and in-water device strikes, but the risk is low. As stated above, only a few ship strike have been documented for this species (Shortnose Sturgeon Status Review Team, 2010). Likewise, smalltooth sawfish are typically found in shallow, coastal waters where testing activities do not occur. When in deeper waters, smalltooth sawfish tend to remain along the seafloor. Nassau grouper are strongly associated with reef and live hardbottom seafloor habitats and, as such, would not be susceptible to vessel and in-water device use.

Vessel and in-water device use potentially overlaps with designated critical habitat for Atlantic salmon, Gulf sturgeon, smalltooth sawfish, and Atlantic sturgeon, but vessel and in-water device use would not impact any of the physical and biological features associated with critical habitat designations. Vessel and in-water device use in smalltooth sawfish critical habitat is extremely unlikely and would not affect the physical and biological identified for these habitats.

Pursuant to the ESA, the use of vessels and in-water devices during testing activities, as described under Alternative 1, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during testing activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.4.1.2 Impacts from Vessels and In-Water Devices under Alternative 2

Impacts from Vessels and In-Water Devices under Alternative 2 for Training Activities

Activities under Alternative 2 would occur at a slightly higher rate and frequency relative to Alternative 1 for certain activities. Therefore, physical disturbance and strike stress experienced by fishes from vessel use and in-water devices under Alternative 2 are expected to be slightly increased in comparison to those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are slightly greater than they are for Alternative 1.

Pursuant to the ESA, the use of vessels and in-water devices during training activities, as described under Alternative 2, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during training activities under Alternative 2 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon.

Impacts from Vessels and In-Water Devices under Alternative 2 for Testing Activities

Because testing activities under Alternative 2 would occur at the same rate and frequency relative to Alternative 1, physical disturbance and strike stress experienced by fishes from vessel use and in-water device under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of vessels and in-water devices during testing activities, as described under Alternative 2, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during testing activities under Alternative 2 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon.

3.6.3.4.1.3 Impacts from Vessels and In-Water Devices under the No Action Alternative

Impacts from Vessels and In-Water Devices under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various physical strike stressors to fishes from vessels or in-water devices would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4.2 Impacts from Aircraft and Aerial Targets

Aircraft and aerial targets stressors are not applicable to fishes because they are conducted in the air and not underwater and will not be analyzed further in this section.

3.6.3.4.3 Impacts from Military Expended Materials

Navy training and testing activities in the Study Area include firing a variety of weapons and employing a variety of explosive and non-explosive rounds including bombs; small-, medium-, and large-caliber projectiles; or sinking exercises with ship hulks. During these training and testing activities, various items may be introduced and expended into the marine environment and are referred to as military expended materials.

This section analyzes the disturbance or strike potential to fishes of the following categories of military expended materials: (1) non-explosive practice munitions, (2) fragments from high-explosive munitions, and (3) expended materials other than munitions, such as sonobuoys, ship hulks, and expendable targets. Section 3.0.3.3.4.2 (Military Expended Materials) provides information on the quantity and location where various types of military expended materials would occur under each alternative. Appendix F (Military Expended Materials and Direct Strike Impact Analyses) provides additional information on each military expended material proposed to be used, where it would be used, how many would be used, and the amount of area impacted by each material. Analysis of all potential impacts (disturbance, strike) of military expended materials on critical habitat is included in this section.

While disturbance or strike from any of these objects as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most fishes. Therefore, with the exception of sinking exercises, the discussion of military expended materials strikes focuses on strikes at the surface or in the upper water column from fragments (of high-explosives) and projectiles because those items have a greater potential for a fish strike as they hit the water, before slowing down as they move through the water column.

Ship Hulk. During a sinking exercise, aircraft, ship, and submarine crews fire or drop munitions on a seaborne target, usually a clean deactivated ship (Section 3.2, Sediments and Water Quality), which is deliberately sunk using multiple weapon systems. A description of Sinking Exercises is presented in Appendix A (Navy Activity Descriptions). Sinking exercises occur in specific open ocean areas, outside of the coastal range complexes, in waters exceeding 3,000 m (9,842.5 ft.) in depth. Direct munitions strikes from the various weapons used in these exercises are a source of potential impact. However, these impacts are discussed for each of those weapons categories in this section and are not repeated in the respective sections. Therefore, the analysis of sinking exercises as a strike potential for benthic fishes is discussed in terms of the ship hulk landing on the seafloor.

Small-, Medium-, and Large-Caliber Projectiles. Various types of projectiles could cause a temporary (seconds), localized impact when they strike the surface of the water. Current Navy training and testing in the Study Area, such as gunnery exercises and testing events, include firing a variety of weapons and using a variety of non-explosive training and testing rounds, including 5-in. naval gun shells, and small-, medium-, and large-caliber projectiles. The larger-caliber projectiles are primarily used in the open ocean beyond 20 NM. Direct munitions strikes from firing weapons are potential stressors to fishes. There is a remote possibility that an individual fish at or near the surface may be struck directly if it is at the point of impact at the time of non-explosive practice munitions delivery. Expended rounds may strike the water surface with sufficient force to cause injury or mortality. However, limited fish species swim right at, or near, the surface of the water (e.g., with the exception of pelagic sharks, herring, salmonids, flying fishes, jacks, tuna, mackerels, billfishes, ocean sunfish, and other similar species).

Various projectiles would fall on soft or hard bottom habitats, where they could either become buried immediately in the sediments, or sit on the bottom for an extended time period. Most munitions would sink through the water column and come to rest on the seafloor, stirring up sediment and possibly inducing an alarm response, displacing, or injuring nearby fishes in extremely rare cases. Particular impacts on a given fish species would depend on the size and speed of the munitions, the water depth, the number of rounds delivered, the frequency of training and testing, and the sensitivity of the fish (U.S. Department of the Navy, 2013).

Bombs, Missiles, and Rockets. Direct munitions strikes from bombs, missiles, and rockets are potential stressors to fishes. Some individual fish at or near the surface may be struck directly if they are at the point of impact at the time of non-explosive munitions delivery. However, most missiles hit their target or are disabled before hitting the water. Thus, most of these missiles and aerial targets hit the water as fragments, which quickly dissipates their kinetic energy within a short distance of the surface. A limited number of fishes swim right at, or near, the surface of the water, as described for small-, medium-, and large-caliber projectiles.

Even though statistical modeling conducted for the Study Area (discussed in Appendix F, Military Expended Materials and Direct Strike Impact Analyses) indicates that the probability of military expended materials striking marine mammals or sea turtles is extremely low, modeling could not be conducted to estimate the probability of military expended material strikes on an individual fish. This is primarily due to the lack of fish density data available at the scale of a range complex or testing range.

In lieu of strike probability modeling, the number, size, and area of potential impact (or "footprints") of each type of military expended material is presented in Appendix F (Military Expended Materials and Direct Strike Impact Analyses).

The application of this type of footprint analysis to fish follows the notion that a fish occupying the impact area could be susceptible to potential impacts, either at the water surface (e.g., pelagic sharks, herring, salmonids, flying fishes, jacks, tuna, mackerels, billfishes, and ocean sunfish (Table 3.6-2) or as military expended material falls through the water column and settles to the bottom (e.g., flounders, skates, and other benthic fishes listed in Table 3.6-2). Furthermore, most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small portion of those would hit the water with their maximum velocity and force. Of that small portion, a small number of fishes at or near the surface (pelagic fishes) or near the bottom (benthic fishes) may be directly impacted if they are in the target area and near the expended item that hits the water surface (or bottom).

Propelled fragments are produced by an exploding bomb. Close to the explosion, fishes could potentially sustain injury or death from propelled fragments (Stuhmiller et al., 1991). However, studies of underwater bomb blasts show that fragments are large and decelerate rapidly (O'Keeffe & Young, 1984; Swisdak & Montanaro, 1992), posing little risk to marine organisms.

Fish disturbance or strike could result from bomb fragments (after explosion) falling through the water column in very small areas compared to the vast expanse of the testing ranges range complexes, or the remainder of the Study Area. The expected reaction of fishes exposed to military expended materials would be to immediately leave the area where bombing is occurring, thereby reducing the probability of a fish strike after the initial expended materials hit the water surface. When a disturbance of this type concludes, the area would be repopulated and the fish stock would rebound, with inconsequential impacts on the resource (Lundquist et al., 2010).

3.6.3.4.3.1 Impacts from Military Expended Materials under Alternative 1

Impacts from Military Expended Materials under Alternative 1 for Training Activities

As stated above, Section 3.0.3.3.4.2 (Military Expended Materials) provides information on the quantity and location where various types of military expended materials would occur under each alternative, while Appendix F (Military Expended Materials and Direct Strike Impact Analyses) has more information on where the military expended material would be used, how many would be used, and the amount of area impacted by each material.

Major fish groups identified in Table 3.6-2 that are particularly susceptible to military expended material strikes are those occurring at the surface, within the offshore and continental shelf portions of the range complexes (where the strike would occur). Those groups include pelagic sharks, herring, salmonids, flying fishes, jacks, tuna, mackerels, billfish, ocean sunfish, and other similar species (Table 3.6-2). Additionally, certain deep-sea fishes would be exposed to strike risk as a ship hulk, expended during a sinking exercise, settles to the seafloor. These groups include hagfish, dragonfish, lanternfishes, Aulopiformes, anglerfishes, and oarfishes.

Projectiles, bombs, missiles, rockets, and associated fragments have the potential to directly strike fish as they hit the water surface and below the surface to the point where the projectile loses its forward momentum. Fishes at and just below the surface would be most susceptible to injury or death from strikes, because velocity of these materials would rapidly decrease upon contact with the water and as they travel through the water column. Consequently, most water column fishes would have ample time to detect and avoid approaching munitions or fragments that fall through the water column. Even for an extreme case of expending all small-caliber projectiles within a single gunnery box, the probability of any of these items striking a fish (even as large as bluefin tuna or whale sharks) is extremely low. Therefore, since most fishes are smaller than bluefin tuna or whale sharks, and most military expended materials are less abundant than small-caliber projectiles, the risk of strike by these items is exceedingly low for fish overall. A possibility exists that a small number of fish at or near the surface may be directly impacted if they are in the target area and near the point of physical impact at the time of military expended material strike, but population-level impacts would not occur.

Sinking exercises occur in open ocean areas, outside of the coastal range complexes. While serious injury or mortality to individual fish would be expected if they were present within range of high-explosive activities (analyzed in Section 3.6.3.1, Acoustic Stressors), sinking exercises under Alternative 1 would not result in impacts on pelagic fish populations at the surface based on the placement of these activities in deep ocean areas where fish abundance is low or widely dispersed. Also, these activities are very few in number. Disturbances to benthic fishes from sinking exercises would be highly localized to the sinking exercise box. Any deep-sea fishes on the bottom where a ship hulk would settle could experience displacement, injury, or death. However, population level impacts on the deep-sea fish community would not occur because of the limited spatial extent of the impact and the wide dispersal of fish in deep ocean areas.

All of the ESA-listed fish species occurring in training areas would be potentially exposed to military expended materials. The Atlantic salmon occurs only in the Northeast Range Complexes and in the three northernmost Large Marine Ecosystems, where the density of military expended materials is very low. Therefore, while military expended materials could overlap with Atlantic salmon, the likelihood of a strike would be extremely low, with discountable effects. Within the Study Area, scalloped hammerhead sharks belonging to the Central and Southwestern Atlantic Distinct Population Segment occur only in the North Atlantic Gyre Open Ocean Area, the Caribbean Sea Large Marine Ecosystem and around Puerto Rico, and the southeastern portion of the Gulf of Mexico Large Marine Ecosystem adjacent to the Key West OPAREA. Therefore, while military expended materials could overlap with scalloped hammerhead sharks, the likelihood of a strike would be extremely low, with discountable effects. Nassau groupers are found in reefs areas of the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems. Even though there's likely some overlap with military expended materials and Nassau grouper, the likelihood of a strike would be extremely low, with discountable effects. All sturgeon are restricted to the continental shelf, particularly the shallow, coastal, or nearshore waters of the Study Area (Dadswell, 2006; Ross et al., 2009) and, therefore, could be exposed to military expended materials in these locations. Sawfishes typically occur in shallow coastal waters of South Florida and the Gulf of Mexico, usually near the ocean bottom, but may occur out to depths of 120 m.

Giant manta rays and oceanic whitetip sharks may occur anywhere within the Study Area as far north as New Jersey. Therefore, the giant manta ray has the potential to be present in most areas where training activities involving the use of military expended materials occur. As giant manta rays and oceanic whitetip sharks are often found near surface waters, it is possible that they may be struck by projectiles and other military expended materials as they enter the water. However, given the scarcity of these species, it is highly unlikely that a giant manta ray or oceanic whitetip shark would be present at a given time or place that an activity is taking place. There is no overlap of military expended materials use with designated critical habitat for Atlantic salmon or smalltooth sawfish. All of the physical and biological features required by Atlantic salmon within the Study Area are applicable to freshwater only and are outside of areas where military materials may be expended. Therefore, none of the military expended materials would affect Atlantic salmon critical habitat. The physical and biological features for smalltooth sawfish critical habitat are red mangrove habitats and shallow marine waters of less than 1 m deep. No activities involving military expended materials would occur at these depths and thus would not overlap with smalltooth sawfish critical habitat. Military expended materials could be expended within Gulf sturgeon critical habitat within coastal waters where the Panama City Operating Area overlaps with the critical habitat. Likewise, the use of military expended materials during training activities overlaps with the designated critical habitat for Atlantic sturgeon in the James and York rivers in Virginia, the Cooper River in South Carolina, and the Savannah River in Georgia. In each case for both Gulf and Atlantic sturgeon critical habitat, while overlap occurs, military expended materials from training exercises are not anticipated to impact any of the physical and biological features identified for these habitats.

The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). The mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

The impact of military expended material strikes on fishes would be inconsequential due to: (1) the limited number of species found directly at the surface where military expended material strikes could occur, (2) the rare chance that a fish might be directly struck at the surface by military expended materials, (3) the ability of most fishes to detect and avoid an object falling through the water below the surface, and (4) the implementation of mitigation. The potential impacts of military expended material strikes would be short term (seconds) and localized disturbances of the water surface (and seafloor areas within sinking exercise boxes) and are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction at the population level.

Pursuant to the ESA, military expended material from training activities, as described under Alternative 1, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Military Expended Materials under Alternative 1 for Testing Activities

Appendix F (Military Expended Materials and Direct Strike Impact Analyses) has more information on the type and quantities of military expended materials proposed to be used. The type, quantity, and location of testing activities would be substantially less than training activities described above.

Potential impacts from military expended material strikes on marine fish groups and ESA-listed species during testing activities would be similar to those described for comparable training activities. Some fish species potentially impacted by testing activities would be different than those fishes impacted during training activities based on the specific activity and the location of the activity. For example, torpedoes are tested at nine locations (Table 3.0-26 and Table 3.0-28) compared to four training locations (Table 3.0-24 and Table 3.0-27). Military expended materials hitting the water could result in an extremely unlikely strike of an individual fish, or more likely in a short-term and local displacement of fishes in the water column. However, these behavioral reactions are not expected to result in substantial changes to an individual's fitness or species recruitment, and are not expected to result in population-level impacts.

Similarly, military expended materials are not anticipated to overlap with designated critical habitat for Atlantic salmon, smalltooth sawfish, or Atlantic sturgeon. Military expended materials could be expended within Gulf sturgeon critical habitat within coastal waters where the Panama City Operating Area overlaps with the critical habitat. While overlap with Gulf sturgeon critical habitat may occur, military expended materials from testing exercises are not anticipated to impact any of the physical and biological features identified for these habitats.

The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). The mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

The impact of military expended material strikes would be inconsequential due to: (1) the limited number of species found directly at the surface where military expended material strikes could occur, (2) the rare chance that a fish might be directly struck at the surface by military expended materials, (3) the ability of most fishes to detect and avoid an object falling through the water below the surface, and (4) the implementation of mitigation. The potential impacts of military expended material strikes would range from short-term (seconds) and localized disturbances of the water surface and long-term impacts for individuals if struck. However, these impacts are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction at the population level.

Pursuant to the ESA, military expended material from testing activities, as described under Alternative 1, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.4.3.2 Impacts from Military Expended Materials under Alternative 2

Impacts from Military Expended Materials under Alternative 2 for Training Activities

Even though the number of military expended materials used during training activities under Alternative 2 would be slightly greater relative to Alternative 1 (see Section 3.0.3.3.4.2, Military Expended Materials), the difference is negligible. Physical disturbance and strike stress experienced by fishes from military expended materials under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended material from training activities, as described under Alternative 2, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Military Expended Materials under Alternative 2 for Testing Activities

Even though the number of military expended materials used during testing activities under Alternative 2 would be slightly greater relative to Alternative 1 (see Section 3.0.3.3.4.2, Military Expended Materials), the difference is negligible. Physical disturbance and strike stress experienced by fishes from military expended materials under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended material from testing activities, as described under Alternative 2, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.4.3.3 Impacts from Military Expended Materials under the No Action Alternative

Impacts from Military Expended Materials under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various military expended materials stressors for fishes would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4.4 Impacts from Seafloor Devices

The number and location of activities including seafloor devices is presented in Section 3.0.3.3.4.3 (Seafloor Devices). Additional information on stressors by testing and training activity is provided in Appendix B (Activity Stressor Matrices). Seafloor devices include items that are placed on, dropped on, or moved along the seafloor, such as mine shapes, anchor blocks, anchors, bottom-placed instruments, bottom-crawling unmanned underwater vehicles, and bottom-placed targets that are not expended. As discussed in the military expended materials strike section, objects falling through the water column would slow in velocity as they sink toward the bottom and could be avoided by most, if not all fish.

Seafloor devices with a strike potential for fish include those items temporarily deployed on the seafloor. The potential strike impacts of unmanned underwater vehicles (e.g., bottom crawl vehicles) are also included here. Some fishes are attracted to virtually any tethered object in the water column for food or refuge (Dempster & Taquet, 2004) and could be attracted to a non-explosive mine assembly. However, while a fish might be attracted to the object, its sensory abilities allow it to avoid colliding with fixed tethered objects in the water column (Bleckmann & Zelick, 2009), so the likelihood of a fish striking one of these objects is implausible. Therefore, strike hazards associated with collision into other seafloor devices such as deployed mine shapes or anchored devices are highly unlikely to pose any strike hazard to fishes and are not discussed further.

3.6.3.4.4.1 Impacts from Seafloor Devices under Alternative 1

Impacts from Seafloor Devices under Alternative 1 for Training Activities

Table 3.0-35 shows the number and location of activities that use seafloor devices. As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, training activities that deploy seafloor devices occur in the Northeast and Southeast U.S. Continental Shelf, Caribbean, and Gulf of Mexico Large Marine Ecosystems and the Gulf Stream Open Ocean Area—specifically within seven locations, including Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Key West Range Complex, Gulf of Mexico Range Complex, Naval Surface Warfare Center Panama City Testing Range, and several inshore water locations (see Table 3.0-36).

Aircraft deployed mine shapes, anchor blocks, anchors, and bottom-placed instruments, and targets all have the potential to strike fish upon deployment as they are sinking through the water column and settling on the seafloor. While seafloor device use during training activities could overlap with ESA-listed species, with the exception of Atlantic salmon, the likelihood of a strike would be extremely low given the low abundance of ESA-listed species recorded in the Study Area, the ability for the species to detect and avoid falling objects through the water below the surface, and the dispersed nature of the activities. However, there would be the potential for effect.

Activities that employ seafloor devices would overlap the critical habitat of the Atlantic sturgeon and Gulf sturgeon. For example, the use of seafloor devices during training activities would overlap designated critical habitat for Atlantic sturgeon in inshore waters such as the Delaware River in Delaware, James and York rivers in Virginia and Savannah and St. Marys rivers in Georgia and with Gulf sturgeon critical habitat within coastal waters where the Panama City Operating Area overlaps with the critical habitat. Seafloor device use would not overlap with designated Atlantic salmon and smalltooth sawfish critical habitat.

The Navy will implement mitigation that includes not conducting precision anchoring (except in designated anchorages) within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks to avoid potential impacts from seafloor devices on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). This mitigation will consequently help avoid potential impacts on fishes that inhabit these areas.

Pursuant to the ESA, the use of seafloor devices during training activities, as described under Alternative 1, would have no effect on Atlantic salmon and designated critical habitat for Atlantic salmon and smalltooth sawfish. The use of seafloor devices during training activities may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Atlantic sturgeon and Gulf sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Seafloor Devices under Alternative 1 for Testing Activities

Table 3.0-35 shows the number and location of activities that use seafloor devices. As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, testing activities that deploy seafloor devices occur in the Northeast Range Complexes, Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Key West Range Complex, Gulf of Mexico Range Complex, Naval Undersea Warfare Center Newport Testing Range, South Florida Ocean Measurement Facility, and Naval Surface Warfare Center Panama City Testing Range.

As discussed in Section 3.6.3.4.3 (Impacts from Military Expended Materials), objects falling through the water column would slow in velocity as they sink toward the bottom and could be avoided by most fishes. While seafloor device use during training activities could overlap with ESA-listed species, the likelihood of a strike would be extremely low given the low abundance of ESA-listed species recorded in the Study Area, the ability for the species to detect and avoid falling objects through the water below the surface, and the dispersed nature of the activities. However, there would be the potential for effect.

Activities that employ seafloor devices would overlap the critical habitat of Gulf sturgeon. For example, the use of seafloor devices during testing activities would overlap with Gulf sturgeon critical habitat within coastal waters in the Panama City Operating Area. Seafloor device use would not overlap with designated Atlantic salmon, Atlantic sturgeon, and smalltooth sawfish critical habitat.

The Navy will implement mitigation to avoid potential impacts from seafloor devices on seafloor resources in mitigation areas within the South Florida Ocean Measurement Facility, as discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources). For example, the Navy will use real-time geographic information system and global positioning system (along with remote sensing verification) during deployment, installation, and recovery of anchors and mine-like objects to avoid impacts on shallow-water coral reefs and live hard bottom. This mitigation will consequently help avoid potential impacts on fishes that occur in these areas.

Pursuant to the ESA, the use of seafloor devices during testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, and smalltooth sawfish. The use of seafloor devices during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Gulf sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.4.4.2 Impacts from Seafloor Devices under Alternative 2

Impacts from Seafloor Devices under Alternative 2 for Training Activities

Because training activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, physical disturbance and strike stress experienced by fishes from seafloor device use under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of seafloor devices during training activities, as described under Alternative 2, would have no effect on Atlantic salmon and designated critical habitat for Atlantic salmon and smalltooth sawfish. The use of seafloor devices during training activities may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Atlantic sturgeon and Gulf sturgeon.

Impacts from Seafloor Devices under Alternative 2 for Testing Activities

Because testing activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, physical disturbance and strike stress experienced by fishes from seafloor device use under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of seafloor devices during testing activities, as described under Alternative 2, would have no effect on Atlantic salmon or designated critical habitat for Atlantic salmon, Atlantic sturgeon, and smalltooth sawfish. The use of seafloor devices during testing activities may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and

Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Gulf sturgeon.

3.6.3.4.4.3 Impacts from Seafloor Devices under the No Action Alternative

Impacts from Seafloor Devices under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Stressors for fishes such as seafloor devices would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4.5 Impacts from Pile Driving

Impact pile driving and vibratory pile removal would occur during training for the construction of an Elevated Causeway System, as described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.3-2. This activity was considered as a potential physical disturbance stressor. Section 3.0.3.3.1.3 (Pile Driving) provides additional details on pile driving and noise levels measured from similar construction activity. Pile driving during construction of an Elevated Causeway System would not occur during testing activities in the AFTT Study Area.

While impacts to fishes from pile driving activities as an acoustic stressor are addressed Section 3.6.3.1.4 (Impacts from Pile Driving), this section addresses the physical presence of the resulting temporary pier as part of the Elevated Causeway System as a potential physical disturbance stressor. The size of the pier would be no greater than 1,520 feet long, consisting of 119 supporting piles, on the beach and out into shallow coastal waters of Joint Expeditionary Base Little Creek-Fort Story in the Virginia Capes Range Complex or Marine Corps Base Camp Lejeune in the Navy Cherry Point Range Complex. Given the nearshore locations for this training activity and the temporary nature of the structures, it is not likely that fishes would experience physical disturbance from the presence of the temporary pier structure. Furthermore, it is not likely that a fish would be struck by a piling during installation because they are mobile and would be able to avoid the physical disturbance and strike stressors. Although some ESA-listed species such as Atlantic sturgeon, shortnose sturgeon, and giant manta rays may be present in the vicinity of pile driving activities, it is also unlikely that they would be struck by a pile. In addition, there is also no overlap between pile driving activities and the designated critical habitats for any ESA-listed species. Therefore, the Navy has determined that the Elevated Causeway System training activity would not result in physical disturbance or strike impacts above those acoustic impacts described in Section 3.6.3.1.4 (Impacts from Pile Driving) and are not considered further in this section.

Physical disturbance and strike stressors from pile driving are not applicable to fishes because pile driving does not occur during testing activities. Pursuant to the ESA, the use of driving during training activities would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Pile driving during training activities would have no effect on Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5 Entanglement Stressors

This section evaluates potential entanglement impacts of various types of expended materials used by the Navy during training and testing activities within the Study Area. The likelihood of fishes being affected by an entanglement stressor is a function of the physical properties, location, and buoyancy of the object and the behavior and physical features of the fish, as described in Section 3.0.3.6.4 (Conceptual Framework for Assessing Effects from Entanglement). Three types of military expended materials are considered here: (1) wires and cables (2) decelerators/parachutes, and (3) biodegradable polymer.

Most entanglement observations involve abandoned or discarded nets, lines, and other materials that form loops or incorporate rings (Derraik, 2002; Keller et al., 2010; Laist, 1987; Macfadyen et al., 2009). A 25-year dataset assembled by the Ocean Conservancy reported that fishing line, rope, and fishing nets accounted for 68 percent of fish entanglements, with the remainder due to encounters with various items such as bottles, cans, and plastic bags (Ocean Conservancy, 2010). No occurrences involving military expended materials were documented.

Fish entanglement occurs most frequently at or just below the surface or in the water column where objects are suspended. A smaller number involve objects on the seafloor, particularly abandoned fishing gear designed to catch bottom fishes or invertebrates (Ocean Conservancy, 2010). More fish species are entangled in coastal waters and the continental shelf than elsewhere in the marine environment because of higher concentrations of human activity (e.g., fishing, sources of entangling debris), higher fish abundances, and greater species diversity (Helfman et al., 2009; Macfadyen et al., 2009). The consequences of entanglement range from temporary and inconsequential to major physiological stress or mortality.

Some fishes are more susceptible to entanglement in derelict fishing gear and other marine debris, compared to other fish groups. Physical features, such as rigid or protruding snouts of sawfishes and sturgeon and some elasmobranchs (e.g., the wide heads of hammerhead sharks and cephalic fins on manta rays), increase the risk of entanglement compared to fishes with smoother, more streamlined bodies (e.g., lampreys and eels). High rates of shark mortality have been associated with entanglement in fish aggregating devices (Filmalter et al., 2013). Sawfishes occur only in nearshore, and continental shelf waters of the Gulf of Mexico Large Marine Ecosystem and portions of the Southeast U.S. Continental Shelf Large Marine Ecosystem (74 *Federal Register* 45353 and 74 *Federal Register* 37671), where they are concentrated in south Florida and the Florida Keys. Scalloped hammerhead sharks, giant manta rays, oceanic whitetip sharks, and ESA-listed sturgeon species occur in nearshore and offshore waters within one or more of the Large Marine Ecosystems that overlap Navy training and testing areas in the Study Area. Most fishes, except for jawless fishes and eels that are too smooth and slippery to become entangled, are susceptible to entanglement in gear specifically designed for that purpose (e.g., gillnets). The Navy uses a biodegradable polymer to function as entanglement objects. Biodegradable polymer systems designed to entangle the propellers of small in-water vessels would only be used during testing activities, not during training and the number and location of proposed testing activities is presented in Table 3.0-42.

The overall impacts of entanglement are highly variable, ranging from temporary disorientation to mortality due to predation or physical injury. The evaluation of a species' entanglement potential should consider the size, location, and buoyancy of an object as well as the size, physical characteristics, and behavior of the fish species.

The following sections seek to identify entanglement potential due to military expended material. Where appropriate, specific geographic areas (Large Marine Ecosystems, open ocean areas, range complexes, testing ranges, and bays and inshore waters) of potential impact are identified.

3.6.3.5.1 Impacts from Wires and Cables

Fiber optic cables, guidance wires, and sonobuoys (which contain a wire) are used during training and testing activities. The number and location of items expended under each alternative is presented in Sections 3.0.3.3.5.1 (Wires and Cables), with additional details on types of activities that include this stressor provided in Appendix B (Activity Stressor Matrices, Tables B-1 and B-2).

Some fiber optic cables used during Navy training and testing associated with remotely operated mine neutralization activities would be expended, although a portion may be recovered. The length of the expended tactical fiber would vary (up to about 3,000 m) depending on the activity. Tactical fiber has an 8-micrometer (0.008 mm) silica core and acylate coating, and looks and feels like thin monofilament fishing line. Other characteristics of tactical fiber are a 242-micrometer (0.24 mm) diameter, 12 lb. tensile strength, and 3.4-mm bend radius (Corning Incorporated, 2005; Ratheon, 2015). Tactical fiber is relatively brittle; it readily breaks if knotted, kinked, or abraded against a sharp object. Deployed tactical fibers breaks if looped beyond its bend radius (3.4 mm), or exceeds its tensile strength (12 lb.). If the fiber becomes looped around an underwater object or marine animal, it does not tighten unless it is under tension. Such an event would be unlikely based on its method of deployment and its resistance to looping after it is expended. The tactical fibers are often designed with controlled buoyancy to minimize the fiber's effect on vehicle movement. The tactical fiber would be suspended within the water column during the activity, and then be expended and sink to the seafloor (effective sink rate of 1.45 cm/second [Raytheon, 2015]) where it would be susceptible to abrasion and burial by sedimentation. Additionally, encounter rates with fiber optic cables is limited by the small number that are expended.

Major fish groups identified in Table 3.6-2 that could be susceptible to entanglement in expended cables and wires are those like sawfishes, with elongated snouts lined with tooth-like structures that easily snag on other similar marine debris, such as derelict fishing gear (Macfadyen et al., 2009). Some elasmobranchs (hammerhead sharks and manta rays) and billfishes occurring within the offshore and continental shelf portions of the range complexes and testing ranges (where the potential for entanglement would occur) could be susceptible to entanglement in cables and wires. Species occurring outside the specified areas within these range complexes and testing ranges would not be exposed to fiber optic cables or guidance wires and sonobuoy wires.

Once a guidance wire is released, it is likely to sink immediately and remain on the seafloor. In some cases, the wire may snag on a hard structure near the bottom and remain partially or completely suspended. The types of fish that encounter any given wire would depend, in part, on its geographic location and vertical location in the water column. In any situation, the most likely mechanism for entanglement would involve fish swimming through loops in the wire that tighten around it; however, loops are unlikely to form in a guidance wire or sonobuoy wire because of its size and rigidity (Environmental Sciences Group, 2005).

Because of their physical characteristics, guidance wires and fiber optic cables pose a potential, though unlikely, entanglement risk to susceptible fishes. Analysis of potential entanglement for fishes is based on abandoned monofilament, nylon, and polypropylene lines used in commercial nets. Such derelict fishing gear is abundant in the ocean (Macfadyen et al., 2009) and pose a greater hazard to fishes than the wires expended by the Navy. Fishing gear materials often have breaking strengths that can be up to orders of magnitude greater than that of guidance wire and fiber optic cables (Environmental Sciences Group, 2005), and are far more prone to tangling, as discussed in Section 3.0.3.3.5.1 (Wires and Cables). Fiber optic cables do not easily form loops, are brittle, and break easily if bent, so they pose a negligible entanglement risk. Additionally, the encounter rate and probability of impact from guidance wires and fiber optic cables are low, as few are expended.

Tube-launched optically tracked wire-guided missiles would expend wires in the nearshore or offshore waters of the Navy Cherry Point Range Complex during training only, and are discussed together with torpedo guidance wires because their potential impacts would be similar to those described here for torpedo guidance wires.

Sonobuoys consist of a surface antenna and float unit and a subsurface hydrophone assembly unit. The two units are attached through a thin gauge, dual-conductor, and hard-draw copper strand wire, which is then wrapped by a hollow rubber tubing or bungee in a spiral configuration. The tensile breaking strength of the wire is a maximum of 40.4 lb. (Swope & McDonald, 2013). The length of the cable is housed in a plastic canister dispenser, which remains attached upon deployment. The length of wire that extends out is no more than 1,500 ft. and is dependent on the water depth and type of sonobuoy. Attached to the wire is a kite-drogue and damper disk stabilizing system made of non-woven nylon fabric. The nylon fabric is very thin and can be broken by hand. The wire runs through the stabilizing system, and leads to the hydrophone components. The hydrophone components may be covered by thin plastic netting depending on type of sonobuoy, but pose no entanglement risk. Each sonobuoy has a saltwater-activated polyurethane float that inflates when the sonobuoy is submerged and keeps the sonobuoy components floating vertically in the water column below it. Sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor.

The sonobuoy itself is not considered an entanglement hazard upon deployment (Environmental Sciences Group, 2005), but their components may pose an entanglement hazard once released into the ocean. Aerial-launched sonobuoys are deployed with a decelerator/parachute. Sonobuoys contain cords, electronic components, and plastic mesh that may entangle fish (Environmental Sciences Group, 2005). Open-ocean filter feeding species, such as basking sharks, whale sharks, and manta rays could become entangled in these items, whereas smaller species such as Atlantic herring could become entangled in the plastic mesh in the same manner as a small gillnet. Smalltooth sawfish, scalloped hammerheads, Nassau grouper, giant manta rays, oceanic whitetip sharks, and sturgeon may co-occur with newly expended sonobuoy, as these fishes are found in areas where sonobuoys are expended. Additionally, since most sonobuoys are expended in offshore areas, many other coastal fishes would not encounter or have any opportunity to become entangled in materials associated with sonobuoys, apart from the risk of entanglement in decelerators/parachutes mentioned above.

3.6.3.5.1.1 Impacts from Wires and Cables under Alternative 1

Impacts from Wires and Cables under Alternative 1 for Training Activities

Fiber optic cables may be expended within the Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico range complexes. Given the locations of training activities, Atlantic salmon, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, smalltooth sawfish, oceanic whitetip sharks, and giant manta rays may be exposed to expended cables and wires. Atlantic salmon occur only in the Northeast Range Complexes where the density of expended wires and cables is very low. Atlantic and shortnose sturgeon could encounter fiber optic cables in the Virginia Capes, Navy Cherry Point, or Jacksonville Range Complexes; smalltooth sawfish could occur in the Jacksonville Range Complex as well. Nassau grouper occur in the Jacksonville and Gulf of Mexico range complexes. For sawfishes, early life stages have the same body-type as adults. However, the likelihood of entanglement of early life stages would be less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep)

(National Marine Fisheries Service, 2009e), where no cables or wires would be expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors. Gulf sturgeon could encounter fiber-optic cables because they are expended during training activities where these species are found, including the Gulf of Mexico. Giant manta rays and oceanic whitetip sharks occur in offshore areas in the large marine ecosystems where training activities would occur. While entanglement is possible, these species would be able to break the wires and cables.

Guidance wires may be expended in the Northeast, Virginia Capes, and Jacksonville range complexes, as well as in the designated Sinking Exercise areas. Benthic-associated ESA-listed species, including Atlantic and shortnose sturgeon, and smalltooth sawfish, could encounter guidance wire because they can occur in nearshore waters out to the shelf break, where they feed on the bottom and could become entangled in a guidance wire while feeding. Pelagic species such as Atlantic salmon and oceanic whitetip sharks may encounter guidance wires in the water column. Guidance wires sink too quickly to be transported very far before reaching the seafloor (Environmental Sciences Group, 2005), thus limiting the amount of exposure time for pelagic species. Gulf sturgeon would not be exposed to guidance wires as they would not be expended within the waters of the northern Gulf of Mexico where this species occurs. Fish would rarely encounter guidance wires expended during training activities. If a guidance wire were encountered, the most likely result would be that the fish ignores it, which is an inconsequential and immeasurable effect. In the rare instance where an individual fish became entangled in guidance wire and could not break free, the individual could be impacted as a result of impaired feeding, bodily injury, or increased susceptibility to predators. However, this is an extremely unlikely scenario because the density of guidance wires would be very low, as discussed in Section 3.0.3.3.5.1 (Wires and Cables).

Sonobuoy wires may be expended within any of the range complexes throughout the Study Area. As described above, a sonobuoy wire runs through the stabilizing system and leads to the hydrophone components. The hydrophone components may be covered by thin plastic netting depending on type of sonobuoy, but pose no entanglement risk. This is mainly due to the sonobuoy being made of a single wire that hangs vertically in the water column. Therefore, it would be highly unlikely that a fish, including ESA-listed species would be entangled by a sonobuoy wire.

While individual fish susceptible to entanglement could encounter guidance wires, fiber optic cables, and sonobuoy wires, the long-term consequences of entanglement are unlikely for either individuals or populations because (1) the encounter rate for cables and wires is low, (2) the types of fishes that are susceptible to these items is limited, (3) the restricted overlap with susceptible fishes, and (4) the physical characteristics of the cables and wires reduce entanglement risk to fishes compared to monofilament used for fishing gear. Potential impacts of exposure to guidance wires and fiber optic cables are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of wires and cables during training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish and no effect on Nassau grouper and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks. The use of wires and cables during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Wires and Cables under Alternative 1 for Testing Activities

As discussed in Section 3.0.3.3.5.1 (Wires and Cables), under Alternative 1 testing activities, fiber optic cables, guidance wires, and sonobuoy components that would pose an entanglement risk to marine fishes, including ESA-listed species, would be similar to those described training activities, even though testing activities occur at a higher frequency and in more locations compared to training activities. Testing activities involving wires and cables occur at Virginia Capes Range Complex, Jacksonville Range Complex, Key West Range Complex, Northeast Range Complexes, Navy Cherry Point Range Complex, Gulf of Mexico Range Complex, Naval Undersea Warfare Center Newport Testing Range, Naval Surface Warfare Center Panama City Testing Range, and South Florida Ocean Measurement Facility.

Atlantic salmon would not be as prone to entanglement because they do not possess the morphological features (rigid or protruding snouts) associated with high entanglement rates. ESA-listed species more susceptible to entanglement (sawfish and sturgeon species, scalloped hammerhead sharks, and giant manta rays) and those not as susceptible to entanglement (Atlantic salmon, Nassau grouper, and oceanic whitetip sharks) occur in testing locations, but are unlikely to encounter the guidance wires because of their low densities in the areas where they are expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors. For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of entanglement of early life stages would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep), where no cables or wires would be expended. The Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks may encounter expended cables and wires in the Key West Range Complex, while the Nassau grouper may encounter expended cables and wires in the Key West Range Complex and the South Florida Ocean Measurement Facility.

While individual fish susceptible to entanglement could encounter guidance wires, fiber optic cables, and sonobuoy wires, the long-term consequences of entanglement are unlikely for either individuals or populations because (1) the encounter rate for cables and wires is low, (2) the types of fishes that are susceptible to these items is limited, (3) the restricted overlap with susceptible fishes, and (4) the physical characteristics of the cables and wires reduce entanglement risk to fishes compared to monofilament used for fishing gear. Potential impacts from exposure to guidance wires and fiber optic cables are not expected to result in substantial changes to an individual’s behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of wires and cables during testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. The use of wires and cables during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.5.1.2 Impacts from Wires and Cables under Alternative 2

Impacts from Wires and Cables under Alternative 2 for Training Activities

Because activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, entanglement stress experienced by fishes from guidance wires, fiber optic cables, and sonobuoy wires under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of wires and cables during training activities, as described under Alternative 12, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish and no effect on Nassau grouper and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks. The use of wires and cables during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Wires and Cables under Alternative 2 for Testing Activities

Even though testing activities under Alternative 2 occur at a slightly higher rate and frequency relative to Alternative 1, entanglement stress experienced by fishes from guidance wires, fiber optic cables, and sonobuoy wires under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of wires and cables during testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. The use of wires and cables during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5.1.3 Impacts from Wires and Cables under the No Action Alternative

Impacts from Wires and Cables under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Entanglement stressors for fishes from wires and cables would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.5.2 Impacts from Decelerators/Parachutes

Decelerators/Parachutes of varying sizes are used during training and testing activities. Section 3.0.3.3.5.2 (Decelerators/Parachutes) describes the use and platforms where decelerators/parachutes would be released into the marine environment and therefore present an entanglement risk to fishes. The types of activities that use decelerators/parachutes can be found in Appendix B (Activity Stressor Matrices), the physical characteristics and size of decelerators/parachutes, locations where decelerators/parachutes are used, and the number of decelerator/parachutes that are proposed to be used under each alternative are presented in Section 3.0.3.3.5.2 (Decelerators/Parachutes).

Once a decelerator/parachute has been released to the water, it poses a potential entanglement risk to fishes. The Naval Ocean Systems Center identified the potential impacts of torpedo air launch accessories, including decelerators/parachutes, on fish (U.S. Department of the Navy, 2001a). Unlike other materials in which fish become entangled (such as gill nets and nylon fishing line), the decelerator/parachute is relatively large and visible, reducing the chance that visually oriented fish would accidentally become entangled in it. No cases of fish entanglement have been reported for decelerators/parachutes (Ocean Conservancy, 2010; U.S. Department of the Navy, 2001a). Entanglement in a newly expended decelerator/parachute and its attachment lines while it is in the water column is unlikely because fish generally react to sound and motion at the surface with a behavioral reaction by swimming away from the source (see Section 3.6.3.4.3, Impacts from Military Expended Materials) and would detect the oncoming decelerator/parachute in time to avoid contact. While the decelerator/parachute is sinking, fish would have ample opportunity to swim away from the large moving object. Even if the decelerator/parachute landed directly on a fish, it would likely be able to swim away faster than the decelerator/parachute would sink because the resistance of the water would slow the decelerator/parachute's downward motion.

Once the decelerator/parachute is on the bottom, however, it is feasible that a fish could become entangled in the decelerator/parachute or its attachment lines while diving and feeding, especially in deeper waters where it is dark. If the decelerator/parachute dropped in an area of strong bottom currents, it could billow open and pose a short-term entanglement threat to large fish feeding on the bottom. Benthic fishes with elongated spines could become caught on the decelerator/parachute or lines. Most sharks and other smooth-bodied fishes are not expected to become entangled because their soft, streamlined bodies can more easily slip through potential snares. A fish with spines or protrusions (e.g., some sharks, manta rays, billfishes, sturgeon, or sawfishes) on its body that swam into the decelerator/parachute or a loop in the lines, and then struggled, could become bound tightly enough to prevent escape. Although this scenario is possible based on the structure of the materials and the shape and behavior of fishes, it is not considered a likely event.

3.6.3.5.2.1 Impacts from Decelerators/Parachutes under Alternative 1

Impacts from Decelerators/Parachutes under Alternative 1 for Training Activities

Fish species that could be susceptible to entanglement in decelerators/parachutes are the same as discussed for cables and wires. As discussed in Section 3.0.3.3.5.2 (Decelerators/Parachutes), there are four sizes of parachutes used during training activities. Air-launched sonobuoys deploy a small parachute (18 in. in diameter) to slow their descent to the water and would be deployed primarily in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, and Key West Range Complexes, but may be used anywhere in the Study Area. Air-dropped lightweight torpedoes utilize a small-sized parachute, approximately 48 in. in diameter, for the same purpose. These items would only be deployed in the Virginia Capes and Jacksonville Range Complexes in very small numbers (an annual total of 36). Medium parachutes, approximately 19 ft. in diameter, associated with illumination flares, would be deployed in relatively small numbers (an annual total of 144 throughout the entire Study Area) in the Virginia Capes, Navy Cherry Point, Jacksonville, and Key West Range Complexes. Large (30 to 50 ft. in diameter) and extra-large (82 ft. in diameter) parachutes are both associated with aerial targets (drones). A small number of large parachutes (33 total annually) would be used primarily in the Virginia Capes Range Complex, but may also be used in the Northeast, Jacksonville and Gulf of Mexico Range Complexes. Only five extra-large parachutes would be expended annually, solely in the Virginia Capes Range Complex. Based on the numbers and geographic locations of their use, decelerators/parachutes pose a risk of entanglement for all fish species that occur in the Study Area. Table 3.0-32 shows the number and location of decelerator/parachutes expended during proposed training activities under Alternative 1.

Some elasmobranchs (sawfishes, hammerhead sharks, and manta rays), sturgeon, swordfishes, and billfishes occurring within the offshore and continental shelf portions of the range complexes (where the potential for entanglement would occur) may be more susceptible to entanglement in decelerators/parachutes than most fish species due to their unusual body shape or projections. As described above, the highly maneuverable swimming capabilities of these fishes make it unlikely that any entanglement would occur while the decelerators/parachutes are at the surface or sinking through the water column. It is conceivable that ESA-listed species near the seafloor such as a sawfish or sturgeon could encounter an expended decelerator/parachute that has settled to the bottom. These species could encounter decelerators/parachutes because they can occur at the surface or on the bottom in nearshore waters out to the shelf break.

The Atlantic salmon occurs in offshore areas where decelerators/parachutes would be expended in the Northeast Range Complexes and may encounter decelerators/parachutes in the water column. However, the Atlantic salmon, like all salmonids, is a strong swimmer with a streamlined body that is unlikely to become entangled in decelerators/parachutes or lines. The impacts of entanglement with decelerators/parachutes are discountable because of the low density of decelerators/parachutes expended in this location and the body shape of Atlantic salmon, which makes it unlikely to become entangled.

Sawfishes are highly mobile, visual predators that could easily avoid a floating or suspended decelerator/parachute. If a rare decelerator/parachute encounter by a sawfish led to entanglement, the fish would likely thrash its rostral saw in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. However, this scenario is considered so unlikely that it would be discountable.

For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of entanglement of early life stages would be slightly less than that of adults because nursery habitats are found in very shallow water (less than 1 m deep) (National Marine Fisheries Service, 2009a), where no decelerators/parachutes would be expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors.

Scalloped hammerhead sharks belonging to the Central and Southwest Atlantic Distinct Population Segment may potentially encounter decelerators/parachutes in the Key West Range Complex. Likewise, due to their widespread distribution, giant manta rays may encounter parachutes/decelerators throughout most of the Study Area where these items are used. Both scalloped hammerhead sharks and giant manta rays are highly mobile species that could likely avoid floating or suspended decelerators/parachutes. If a rare decelerator/parachute encounter by one of these species led to entanglement, it would likely thrash in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. However, this scenario is considered so unlikely that it would be discountable. Similarly, oceanic whitetip sharks occurring offshore could come into contact with a parachute/decelerator during training activities. This species is also a highly mobile, visual predator that could easily avoid floating or suspended decelerators/parachutes or break free if it got entangled.

Nassau groupers are found in reefs areas of the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea. However, this species is known to have large spawning aggregations in areas such as the ends of islands or reef pinnacles seaward from the general reef contour. This species is highly mobile and could easily avoid floating or suspended decelerators/parachutes, so the likelihood of this species being entangled would be extremely low. If a rare decelerator/parachute encounter by a Nassau grouper led to entanglement, the fish would likely thrash in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. However, this scenario is considered so unlikely that it would be discountable.

Fishes are unlikely to encounter or become entangled in decelerators/parachutes because of the large size of the range complexes and the resulting widely scattered expended decelerators/parachutes. Individual fish are not prone to be repeatedly exposed to decelerators/parachutes; thus the long-term consequences of entanglement risks from decelerators/parachutes are unlikely for either individuals or populations.

Pursuant to the ESA, the use of decelerators/parachutes during training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Decelerators/Parachutes under Alternative 1 for Testing Activities

As discussed in Section 3.0.3.3.5.2 (Decelerators/Parachutes), under Alternative 1 testing activities, there are four sizes of decelerators/parachutes used. Only small–, medium-, and large-sized parachutes would be expended during testing activities. Small-sized decelerators/parachutes used in conjunction with sonobuoys and light-weight torpedoes and medium-sized decelerators/parachutes, associated with illumination flares, would be used in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes. In addition, small decelerators/parachutes would also be deployed in the Naval Undersea Warfare Center Newport Testing Range, South Florida Ocean Measurement Facility, and Naval Surface Warfare Center Panama City Testing Range (see Table 3.0-34). Large decelerators/parachutes associated with aerial targets (drones) would primarily be used in the Virginia Capes Range Complex but may also be used in the Northeast, Jacksonville, and Gulf of Mexico Range Complexes. Based on the numbers and geographic locations of their use, decelerators/parachutes pose a risk of entanglement for all ESA-listed fish species that occurs in the Study Area. Table 3.0-34 shows the number and location of each type of decelerators/parachutes expended during proposed testing activities under Alternative 1. Appendix F (Military Expended Materials and Direct Strike Impact Analyses) provides locations, quantities, and impact footprints of expended decelerator/parachutes. Table F-14 and F-15 provides the number of each type of military expended material used for testing activities under Alternative 1.

Based on the numbers and geographic locations of their use, decelerators/parachutes pose a risk of entanglement for all fish species that occurs in the Study Area, including ESA-listed species and would be the same as discussed for cables and wires. It is conceivable that a sawfish or sturgeon could encounter an expended decelerator/parachute that has settled to the bottom. Any of the sturgeon species could encounter decelerators/parachutes because sturgeon can occur at the surface or on the bottom in nearshore waters out to the shelf break. For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of entanglement of early life stages would be slightly less than that of adults because nursery habitats are found in very shallow water (less than 1 m deep), where no decelerators/parachutes would be expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors.

Scalloped hammerhead sharks, oceanic whitetip sharks, and manta rays are highly mobile pelagic species and would likely avoid floating or suspended decelerators/parachutes. If one of these species were to become entangled in a decelerator/parachute, they would likely thrash in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. This scenario is considered so unlikely that it would be discountable.

Fish are unlikely to encounter or become entangled in decelerators/parachutes because of the large size of the range complexes and testing ranges and the resulting widely scattered expended decelerators/parachutes. Individual fish are not prone to be repeatedly exposed to these entanglement stressors, thus the long-term consequences of entanglement risks from decelerators/parachutes are unlikely for either individuals or populations.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.5.2.2 Impacts from Decelerators/Parachutes under Alternative 2

<u>Impacts from Decelerators/Parachutes under Alternative 2 for Training Activities</u>

Under Alternative 2, the number of decelerators/parachutes that would be expended during training activities would be similar to Alternative 1 and entanglement stress experienced by fishes from decelerators/parachutes under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, the impact conclusion for decelerators/parachutes under Alternative 2 training activities is the same as for Alternative 1.

Pursuant to the ESA, the use of decelerators/parachutes during training activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

<u>Impacts from Decelerators/Parachutes under Alternative 2 for Testing Activities</u>

Under Alternative 2, the number of decelerators/parachutes that would be expended during testing activities would be similar to Alternative 1 and entanglement stress experienced by fishes from decelerators/parachutes under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, the impact conclusion for decelerators/parachutes under Alternative 2 testing activities is the same as for Alternative 1.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5.2.3 Impacts from Decelerators/Parachutes under the No Action Alternative

Impacts from Decelerators/Parachutes under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Entanglement stressors for fishes from decelerators/parachutes would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.5.3 Impacts from Biodegradable Polymer

For a discussion of the types of activities that use biodegradable polymers see Appendix B (Activity Stressor Matrices) and for a discussion on where they are used and how many activities would occur under each alternative, see Section 3.0.3.3.5.3 (Biodegradable Polymer). Navy activities that involve vessel entanglement systems include the development of the biodegradable polymer and would only be associated with testing activities in the AFTT Study Area. As indicated by its name, vessel entanglement systems that make use of biodegradable polymers are designed to entangle the propellers of vessels, which would significantly slow and potentially stop the advance of the vessel. A biodegradable polymer is a high molecular weight polymer that degrades to smaller compounds as a result of microorganisms and enzymes. The rate of biodegradation could vary from hours to years and the type of small molecules formed during degradation can range from complex to simple products, depending on whether the polymers are natural or synthetic (Karlsson & Albertsson, 1998). Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material would breakdown into small pieces within a few days to weeks. This would breakdown further and dissolve into the water column within weeks to a few months. The final products, which are all environmentally benign, would be dispersed quickly to undetectable concentrations. Unlike other entanglement stressors, biodegradable polymers only retain their strength for a relatively short period of time; therefore, the potential for entanglement by a fish would be limited. Furthermore, the longer the biodegradable polymer remains in the water, the weaker it becomes making it more brittle and likely to break. A fish would have to encounter the biodegradable polymer after it was expended for it to be a potential entanglement risk. If an animal were to approach the polymer more than a few weeks after it was expended, it is very likely that it would break easily and would not be able to entangle a fish. Since biodegradable polymers are only proposed for testing activities within the AFTT Study Area, the concentration of these items being expended throughout the AFTT Study Area is considered very low and the rate of encounter and risk of entanglement for fishes would be considered extremely low.

3.6.3.5.3.1 Impacts from Biodegradable Polymer under Alternative 1

Impacts from Biodegradable Polymer under Alternative 1 for Training Activities

Biodegradable polymers would not be used during Navy training activities associated with the Proposed Action and therefore will not be analyzed in this section.

Impacts from Biodegradable Polymer under Alternative 1 for Testing Activities

Testing activities under Alternative 1 that use of biodegradable polymers would be conducted within the Virginia Capes, Jacksonville, Key West and Gulf of Mexico Range Complexes, as well as the Naval Undersea Warfare Center Newport Testing Range. Biodegradable polymers would be expended equally throughout these areas.

ESA-listed species such as smalltooth sawfish, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, oceanic whitetip sharks, and giant manta rays may occur in these range complexes and may be exposed to the biodegradable polymer during testing activities. However, the likelihood of a fish encountering the biodegradable polymers when they are first expended is low because: (1) very few polymers are used annually within each range complex; and (2) polymers only remain intact for relatively short periods of time (generally a few days to weeks) and they are brittle and would break apart over time.

Pursuant to the ESA, the use of biodegradable polymers during testing activities, as described under Alternative 1, would have no effect on Atlantic salmon and would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of biodegradable polymers during testing activities under Alternative 1 may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.5.3.2 Impacts from Biodegradable Polymer under Alternative 2

Impacts from Biodegradable Polymer under Alternative 2 for Training Activities

Biodegradable polymers would not be used during Navy training activities associated with the Proposed Action and therefore will not be analyzed in this section.

Impacts from Biodegradable Polymer under Alternative 2 for Testing Activities

Testing activities that expend biodegradable polymers under Alternative 2 would be identical to what is proposed under Alternative 1. The analysis presented above in Section 3.6.3.5.3.1 (Impacts from Biodegradable Polymer under Alternative 1) for testing activities would also apply to Alternative 2.

Pursuant to the ESA, the use of biodegradable polymers during testing activities, as described under Alternative 2, would have no effect on Atlantic salmon and would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of biodegradable polymers during testing activities under Alternative 2 may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5.3.3 Impacts from Biodegradable Polymer under the No Action Alternative

Impacts from Biodegradable Polymer under the No Action Alternative for Training and Testing Activities

Biodegradable polymer is not a part of ongoing Navy activities in the Study Area and this entanglement stressor would not be introduced into the marine environment under the No Action Alternative. Therefore, no change in baseline conditions of the existing environment would occur.

3.6.3.6 Ingestion Stressors

This section analyzes the potential ingestion impacts of the various types of munitions and military expended materials other than munitions used by the Navy during training and testing activities within the Study Area. Aspects of ingestion stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.5 (Conceptual Framework for Assessing Effects from Ingestion). Ingestion of expended materials by fishes could occur in all Large Marine Ecosystems and open ocean areas, and can occur at or just below the surface, in the water column, or at the seafloor, depending on the size and buoyancy of the expended object and the feeding behavior of the fish. Floating material is more likely to be eaten by fishes that feed at or near the water surface (e.g., ocean sunfish, basking sharks, whale sharks, manta rays, herring, or flying fishes), while materials that sink to the seafloor present a higher risk to bottom-feeding fishes (e.g., sturgeon, hammerhead sharks, skates, and flatfishes).

It is reasonable to assume that any item of a size that can be swallowed by a fish could be eaten at some time; this analysis focuses on ingestion of materials in two locations: (1) at the surface or water column and (2) at the seafloor. Open-ocean predators and open-ocean planktivores are most likely to ingest materials in the water column. Coastal bottom-dwelling predators and estuarine bottom-dwelling predators could ingest materials from the seafloor. The potential for fish, including the ESA-listed fish species, to encounter and ingest expended materials is evaluated with respect to their feeding group, size, and geographic range, which influence the probability that they would eat military expended materials.

The Navy expends the following types of materials during training and testing in the Study Area that could become ingestion stressors: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and compression pads or pistons), small decelerators/parachutes, and biodegradable polymer. The location and number of expended items that are ingestion stressors are detailed in Section 3.0.3.3.6 (Ingestion Stressors) and the types of activities that include ingestion stressors can be found in in Appendix B (Activity Stressor Matrices). Metal items eaten by fish are generally small (such as fishhooks, bottle caps, and metal springs), suggesting that small- and medium-caliber projectiles are more likely to be ingested. Both physical and toxicological impacts could occur as a result of consuming metal or plastic materials (Dantas et al., 2012; Davison & Asch, 2011; Possatto et al., 2011). Ingestion of plastics has been shown to increase hazardous chemicals in fish leading to liver toxicity of fishes (Rochman et al., 2013). Items of concern are those of ingestible size that either drift at or just below the surface (or in the water column) for a time or sink immediately to the seafloor. The likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish and the rate at which the fish encounters the item and the composition of the item. In this analysis only small- and medium-caliber munitions (or small fragments from larger munitions), chaff, small decelerators/parachutes, and end caps and compression pads or pistons from flares and chaff cartridges are considered to be of ingestible size for a fish. For many small fish species (e.g., herring, anchovy, etc.), even these items (with the exception of chaff) are often too large to be ingested, even though small pieces could sometimes be nibbled off by small fishes. Therefore, the discussion in this section focuses on those fish species large enough to potentially ingest these materials.

The analysis of ingestion impacts on fishes is structured around the following feeding strategies:

Feeding at or Just Below the Surface or Within the Water Column

- **Open-Ocean Predators.** Large, migratory, open-ocean fishes, such as salmon, tuna, dolphin fish, sharks, and billfishes, feed on fast-swimming prey in the water column of the Study Area (Table 3.6-17). These fishes range widely in search of unevenly distributed food patches. Atlantic salmon generally travel alone (Fay et al., 2006) but gather in common feeding areas near Greenland and Labrador, where they prey on schooling fish associated with the surface and water column of shallow open-water areas (Hansen & Windsor, 2006). Smaller military expended materials could be mistaken for prey items and ingested purposefully or incidentally as the fish is swimming. A few of these predatory fishes (e.g., bull sharks, tiger sharks) are known to ingest any type of marine debris that they can swallow, even automobile tires. Some marine fishes, such as the dolphinfish (*Coryphaena hippurus*) (South Atlantic Fishery Management Council, 2011) and tunas, eat plastic fragments, strings, nylon lines, ropes, or even small light bulbs (Choy & Drazen, 2013; Rochman et al., 2015).

Table 3.6-17: Ingestion Stressors Potential for Impact on Fishes Based on Location

Feeding Guild	*Representative Species*	*Endangered Species Act-Protected Species*	*Overall Potential for Impact*
Open-ocean predators	Dolphinfishes, most shark species, tuna, mackerel, wahoo, jacks, billfishes, swordfishes	Atlantic salmon, Scalloped hammerhead sharks, Oceanic whitetip sharks	These fishes may eat floating or sinking expended materials, but the encounter rate would be extremely low. May result in individual injury or death but is not anticipated to have population-level effects.
Open-ocean Plankton Eaters (Planktivores)	Atlantic herrings, Menhaden, basking shark, whale shark	Giant manta rays	These fishes may ingest floating expended materials incidentally as they feed in the water column, but the encounter rate would be extremely low. May result in individual injury or death but is not anticipated to have population-level effects.
Coastal bottom-dwelling predators	Atlantic cod, skates, cusks, and rays	Atlantic salmon, Scalloped hammerhead sharks, Nassau grouper	These fishes may eat expended materials on the seafloor, but the encounter rate would be extremely low. May result in individual injury or death but is not anticipated to have population-level effects.
Coastal bottom-dwelling foragers and scavengers	Skates and rays, flounders	Sturgeon species, Sawfish species	These fishes could incidentally eat some expended materials while foraging, especially in muddy waters with limited visibility. May result in individual injury or death but is not anticipated to have population-level effects.

Note: The scientific names of the listed species are as follows: Atlantic cod (*Hippoglossus hippoglossus*), Atlantic salmon (*Salmo salar*), basking shark (*Cetorhinus maximus*), cusk (*Brosme brosme*), dolphinfish (*Coryphaena hippurus*), whale shark (*Rhincodon typus*), rays (*Manta* spp.), and scalloped hammerhead shark (*Sphyrna lewini*), sawfish species (*Pristis* spp.), sturgeon species (*Acipenser* spp.), rays (*Manta* spp.), skates (*Amblyraja* spp.), and flounders (Bothidae).

- **Open-Ocean Planktivores.** Plankton-eating fishes in the open-ocean portion of the Study Area include herring, flying fishes, ocean sunfish, whale sharks, manta rays, and basking sharks. These fishes feed by either filtering plankton from the water column or by selectively ingesting larger zooplankton. These planktivores could encounter and incidentally feed on smaller types of military expended materials (e.g., chaff, end caps, pistons) at or just below the surface or in the water column (Table 3.6-2). Giant manta rays are the only ESA-listed species in the Study Area that is an open ocean planktivore, while some species in this group of fishes (e.g., herring) constitute a major prey base for many important predators, including salmon, tuna, sharks, marine mammals, and seabirds. While not a consumer of plankton, the ocean sunfish eats jellyfish and may consume a parachute/decelerator by accident at or just below the surface in the open ocean. Larger filter feeders such as whale sharks, basking sharks, and manta rays could also inadvertently ingest a parachute or decelerator.

Military expended materials that could potentially impact these types of fish at or just below the surface or in the water column include those items that float or are suspended in the water column for some period of time (e.g., decelerators/parachutes and end caps and pistons from chaff cartridges or flares).

Fishes Feeding at the Seafloor

- **Bottom Dwelling Predators.** Large predatory fishes near the seafloor are represented by species such as Atlantic cod and cusk, which are typical predators in the northern portion of the Study Area (Table 3.6-17). The cod and cusk feed opportunistically on or near the bottom, taking fishes and invertebrates from the water column (e.g., shrimp) and from the sediment (e.g., crabs) (Collette & Klein-MacPhee, 2002). The cod also ingests marine debris while feeding on or near the bottom. In the United Kingdom, plastic cups thrown from ferries have been discovered in cod stomachs (Hoss & Settle, 1990). The varied diet of the cod and the low visibility in its deep shelf habitat may promote the ingestion of foreign objects. The Atlantic salmon also feeds on fish on or near the seafloor such as sand lances and capelin. Cusks and sturgeon normally eats hard-shelled and spiny organisms, increasing the likelihood that it would swallow a sharp plastic or metal item rather than reject it.

- **Bottom Dwelling Foragers and Scavengers.** Bottom dwelling fishes in the nearshore coasts and estuaries may feed by seeking prey and by scavenging on dead fishes and invertebrates. All sturgeon in the Study Area suction-feed along the bottom in coastal waters on small fish and invertebrate prey, which increases the likelihood of incidental ingestion of marine debris (Ross et al., 2009).

Military expended materials that could be ingested by fishes at the seafloor include items that sink (e.g., small-caliber projectiles and casings, fragments from high-explosive munitions).

Potential impacts of ingestion on some adult fishes are different than for other life stages (eggs, larvae, and juveniles) because early life stages for some species are too small to ingest any military expended materials except for chaff, which has been shown to have limited effects on fishes in the concentration levels that it is released at (Arfsten et al., 2002; U.S. Air Force, 1997; U.S. Department of the Navy, 1999). Therefore, no ingestion potential impacts on early life stages would occur, with the exception of later stage juveniles that are large enough to ingest military expended materials.

Within the context of fish location in the water column and feeding strategies, the analysis is divided into (1) munitions (small- and medium-caliber projectiles, and small fragments from larger munitions, and flechettes); and (2) military expended material other than munitions (chaff, chaff end caps, compression pads or pistons, decelerators/parachutes, flares, and target fragments).

3.6.3.6.1 Impacts from Military Expended Materials – Munitions

Different types of explosive and non-explosive practice munitions are expended at sea during training and testing activities. This section analyzes the potential for fishes to ingest non-explosive practice munitions and fragments from high explosive munitions.

Types of non-explosive practice munitions generally include projectiles, missiles, and bombs. Of these, only small- or medium-caliber projectiles would be small enough for a large fishes to ingest. Small- and medium-caliber projectiles include all sizes up to and including 2.25 in. in diameter. These solid metal materials would quickly move through the water column and settle to the seafloor. Ingestion of non-explosive practice munitions in the water column is possible when shiny fragments of the munitions sink quickly and could be ingested by fast, mobile predators that chase moving prey (e.g., tunas, jacks, billfishes, swordfishes, dolphinfishes, mackerel, wahoo, and barracudas). In addition, these fragments may also be accidentally ingested by fishes that forage on the bottom such as sturgeon, flounders, skates, and rays.

Types of high explosive munitions that can result in fragments include demolition charges, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munitions type; however, typical sizes of fragments are unknown. These solid metal materials would quickly move through the water column and settle to the seafloor. Similar to non-explosive practice munitions described above, ingestion of high explosive munition fragments by fast-moving mobile predators such tunas, jacks, billfishes, swordfishes, dolphinfishes, mackerel, wahoo, and barracudas in the water column is possible, but unlikely. In the unlikely event that explosive material, high-melting-point explosive (known as HMX), or royal demolition explosive (known as RDX), is exposed on the ocean floor, it would break down in a few hours (U.S. Department of the Navy, 2001b). High-melting-point explosive or royal demolition explosive would not accumulate in the tissues of fish (Lotufo et al., 2010; Price et al., 1998). Fragments are primarily encountered by species that forage on the bottom.

It is possible that expended small caliber projectiles on the seafloor could be colonized by seafloor organisms and mistaken for prey or that expended small caliber projectiles could be accidentally or intentionally eaten during foraging. Over time, the metal may corrode or become covered by sediment in some habitats, reducing the likelihood of a fish encountering the small caliber, non-explosive practice munitions.

The potential impacts of ingesting foreign objects on a given fish depend on the species and size of the fish. Fishes that normally eat spiny, hard-bodied invertebrates may have tougher mouths and digestive systems than fish that normally feed on softer prey. Materials that are similar to the normal diet of a fish would be more likely to be ingested and more easily handled once ingested—for example, by fishes that feed on invertebrates with sharp appendages. These items could include fragments from high-explosives that a fish could encounter on the seafloor. Relatively small or smooth objects, such as small-caliber projectiles or their casings, might pass through the digestive tract without causing harm. A small sharp-edged item could cause a fish immediate physical distress by tearing or cutting the mouth, throat, or stomach. If the object is rigid and large (relative to the fish's mouth and throat), it may block the throat or obstruct the flow of waste through the digestive system. An object may be enclosed by a cyst in the gut lining (Danner et al., 2009; Hoss & Settle, 1990). Ingestion of large foreign objects could lead to disruption of a fish's normal feeding behavior, which could be sublethal or lethal.

3.6.3.6.1.1 Impacts from Military Expended Materials – Munitions under Alternative 1

Impacts from Military Expended Materials – Munitions under Alternative 1 for Training Activities

Use of military expended materials from munitions may occur throughout the AFTT Study Area. Fishes in the vicinity of these activities would have the remote potential to ingest military expended materials from munitions.

When these items explode, they may break apart or remain largely intact in irregularly shaped pieces—some of which may be small enough for some fishes to ingest. Some fishes such as sturgeon are able to feed on crustaceans that have hard, sharp, or irregular parts, without any impacts. Most fragments from high-explosives would be too large for a fish to ingest. Also, it is assumed that fragments from larger munitions are similar in size to fragments from smaller munitions. Although fragment size cannot be quantified, more individual fragments would result from larger munitions than from smaller munitions. The number of fragments that would result from the proposed explosions cannot be quantified. However, it is believed to be smaller than the number of small-caliber projectiles to be expended in the Study Area. Small-caliber projectiles would likely be more prevalent throughout the Study Area and more likely to be encountered and potentially ingested by bottom-dwelling fishes and some reef fishes, such as Nassau grouper, than fragments from any type of high-explosive munitions.

The Atlantic and Gulf sturgeon and smalltooth sawfish may occur in portions of the Study Area out to the continental shelf break where projectiles and munitions are used. Shortnose sturgeon can migrate long distances in coastal waters to their natal river or estuary (Wippelhauser et al., 2015), only occasionally moving to nearshore marine environments. The current Chesapeake Bay system population of shortnose sturgeon appears to be centered in the upper Chesapeake Bay (Welsh et al., 2002), outside of the Study Area. Training activities expending projectiles or munitions could expose sturgeon and sawfish to ingestion risk. These species could be injured if it ingested a small-caliber projectile or fragment and couldn't pass it.

Scalloped hammerhead sharks could encounter some munitions-related material; although the likelihood is remote because only medium-caliber projectiles (no small-caliber projectiles) would be expended in the Key West Range Complex portion of the Study Area where this species would most likely occur. Although less likely, smalltooth sawfish could encounter some munitions-related material in the Jacksonville and Gulf of Mexico Range Complexes. Giant manta rays and oceanic whitetip sharks are generally surface-oriented feeders, with rays feeding on plankton in the upper water column, while oceanic whitetips are high-level predators feeding on fishes and cephalopods such as squid. It is unlikely that these species would mistake larger military expended materials in the water column for prey. If these species accidentally ingested military expended materials, it is likely that they would "taste" the item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. It is also possible that giant mantas could ingest smaller fragments as they fall through the water column, although this species would be able to distinguish between a food item and non-food item such as fragments of military expended materials.

The likelihood of ingestion of munitions (or fragments) by early life stages of smalltooth sawfish would be slightly less than that of adults because nursery habitats are found in very shallow water (less than 1 m deep), where no munitions would be expended. Juvenile sturgeon are also found in the same freshwater rivers and tributaries as adults, including the James River, and would also be potentially exposed to ingestion stressors.

Overall, the potential impacts of ingesting munitions (whole or fragments) would be limited to individual fish that might suffer a negative response from a given ingestion event. While ingestion of munitions or fragments identified here could result in sublethal or lethal effects to a small number of individuals, the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, As a fish might "taste" an item, then expel it (Felix et al., 1995), in the same manner that a fish would take a lure into its mouth then spit it out. The number of fishes potentially impacted by ingestion of munitions or fragments from munitions would be assumed to be low, and population-level effects would not be expected. The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for

Seafloor Resources). This mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

Pursuant to the ESA, military expended materials such as munitions from training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Military Expended Materials – Munitions under Alternative 1 for Testing Activities

Use of military expended materials from munitions may occur throughout the AFTT Study Area. Fish in the vicinity of these activities would have the potential to ingest military expended materials from munitions.

When these items explode, they may break apart or remain largely intact in irregularly shaped pieces—some of which may be small enough for a fish to ingest. Some fish species feed on crustaceans that have hard, sharp, or irregular parts, without any impacts. Most fragments from high-explosives would be too large for a fish to ingest. Also, it is assumed that fragments from larger munitions are similar in size to fragments from smaller munitions. Although fragment size cannot be quantified, more individual fragments would result from larger munitions than from smaller munitions. The number of fragments that would result from the proposed explosions cannot be quantified. However, it is believed to be smaller than the number of small-caliber projectiles to be expended in the Study Area. Small-caliber projectiles would likely be more prevalent throughout the Study Area and more likely to be encountered and potentially ingested by bottom-dwelling fishes than fragments from any type of high-explosive munitions. Furthermore, a fish might taste an item then expel it before swallowing it (Felix et al., 1995), in the same manner that fish would temporarily take a lure into its mouth, then spit it out. Based on these factors, the number of fishes potentially impacted by ingestion of munitions would be low and population-level impacts are not likely to occur.

The Atlantic and Gulf sturgeon and smalltooth sawfish may occur in portions of the Study Area out to the continental shelf break where projectiles and munitions are used. Shortnose sturgeon generally remain within their natal river or estuary, only occasionally moving to nearshore marine environments (Dadswell et al., 1984). The current Chesapeake Bay system population of shortnose sturgeon appears to be centered in the upper Chesapeake Bay (Welsh et al., 2002), outside of the Study Area. The likelihood of ingestion of munitions (or fragments) by early life stages of sawfishes would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep), where no munitions would be expended. Early life stages of sturgeon are typically found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to ingestion stressors.

As described above for training activities, giant manta rays and oceanic whitetip sharks are generally surface-oriented feeders. It is unlikely that these species would mistake larger military expended materials in the water column for prey, but if this occurred they accidentally ingested military expended materials, it is likely that they would "taste" the item and then expel it. Smaller fragments could be consumed and these species would be able to distinguish between food and non-food items.

Overall, the impacts on fishes ingesting munitions or fragments from munitions resulting from proposed testing activities would be low. The number of fishes potentially impacted by ingestion of munitions or fragments from munitions would be low, and population-level effects would not be expected. The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). This mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

Pursuant to the ESA, military expended materials such as munitions from testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.6.1.2 Impacts from Military Expended Materials – Munitions under Alternative 2

Impacts from Military Expended Materials – Munitions under Alternative 2 for Training Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials and munitions under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with training and testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials such as munitions from training activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Military Expended Materials – Munitions under Alternative 2 for Testing Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials and munitions under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials such as munitions from testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.6.1.3 Impacts from Military Expended Materials – Munitions under the No Action Alternative

Impacts from Military Expended Materials – Munitions under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Ingestion stressors for fishes from military expended materials such as munitions would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.6.2 Impacts from Military Expended Materials – Other Than Munitions

Fishes feed throughout the water column and could mistake many types of marine debris for prey items. Ingesting nonfood items is common among a variety of marine fishes, particularly those that feed on the seafloor (Boerger et al., 2010; Hoss & Settle, 1990; Jackson et al., 2000). Many fishes are also known to accidentally ingest plastic materials and the extent to which an individual fish might discriminate between a plastic item perceived as prey and an indistinct or less appealing shape is not clear. Once eaten, any type of plastic could cause digestive problems for the fish (Danner et al., 2009). Fishes have been reported to ingest a variety of materials or debris, such as plastic pellets, bags, rope, and line (Hoss & Settle, 1990; Jackson et al., 2000). As discussed above in Section 3.6.3.6 (Ingestion Stressors), some fish species such as the ocean sunfish eat jellyfish and may consume a parachute/decelerator at or just below the surface in the open ocean by accident. Larger filter feeders such as whale sharks, basking sharks, and manta rays could also inadvertently ingest a small or medium parachute or decelerator.

Chaff is used throughout the Study Area and is composed of an aluminum alloy coating on glass fibers of silicon dioxide and is released or dispensed in cartridges or projectiles that contain millions of fibers. Based on the small size of chaff fibers, fishes would likely not confuse the fibers with prey items or purposefully feed on them. However, some fishes could occasionally ingest low concentrations of chaff incidentally while feeding on prey items on the surface, in the water column, or the seafloor. Chaff fiber ingestion is not expected to impact fishes based on the low concentration that could reasonably be ingested and the small size of the chaff fibers. Therefore, exposure to chaff would cause no injury, mortality, or tissue damage to fishes. Potential impacts of chaff ingestion by fishes are not discussed further. Impacts of ingestion of the end caps, pistons, or compression pads associated with chaff cartridges are analyzed together with impacts of flares below.

Chaff end caps and pistons sink in saltwater (U.S. Department of the Navy, 1999). Fishes feeding on the seafloor where chaff canisters and flares are expended (e.g., range complexes, and testing ranges) would be more likely to encounter and ingest these items than in other locations. Ingested end caps or pistons could disrupt a fish’s feeding behavior or digestive processes. If the item is particularly large relative to the fish ingesting it, the item could become permanently encapsulated by the stomach lining, and potentially lead to starvation and death (Danner et al., 2009 ; Hoss & Settle, 1990).

As described above, surface-feeding fishes have little opportunity to ingest end caps, pistons, or compression pads before they sink. However, some of these items could become entangled in dense *Sargassum* mats near the surface. Predatory open-ocean fishes, such as tuna, dolphinfishes, and billfishes, are attracted to the many small prey species associated with *Sargassum* mats. While foraging near the floating mats, predatory fishes may incidentally ingest end caps and pistons. The density of these items in any given location would vary based on release points and dispersion by wind and water currents. The number of end caps, pistons, or compression pads that would remain at or just below the surface in *Sargassum* mats and potentially available to fish is unknown. Unlike other plastic types of marine debris, end caps, pistons, and compression pads are heavier than water and not expected to float unless they are enmeshed in *Sargassum* or other floating debris.

Most materials associated with airborne mine neutralization system activities are recovered, but pieces of fiber optic cable may be expended (U.S. Department of the Navy, 2001a). For a discussion of the physical characteristics of these expended materials, where they are used, and the number of activities, please see Section 3.0.3.3.5.1 (Wires and Cables). Only small amounts of fiber optic cable would be deposited onto the seafloor each year, and the small amount of fiber optic cable expended during training and testing would sink to the seafloor. Pelagic fishes would be unlikely to encounter the small, dispersed lengths of fiber optic cable unless they were in the immediate area when the cable was expended. The low number of fiber optic cables expended in the Study Area during this activity makes it unlikely that fishes would encounter any fiber optic cables. Potential impacts of fiber optic cable ingestion by fishes are not discussed further.

As stated in Section 3.0.3.3.5.3 (Biodegradable Polymer), based on the constituents of the biodegradable polymer, it is anticipated that the material will breakdown into small pieces within a few days to weeks. These small pieces will breakdown further and dissolve into the water column within weeks to a few months and could potentially be incidentally ingested by fishes. Because the final products of the breakdown are all environmentally benign, the Navy does not expect the use of biodegradable polymer to have any negative impacts for fishes.

3.6.3.6.2.1 Impacts from Military Expended Materials – Other Than Munitions under Alternative 1

Impacts from Military Expended Materials – Other Than Munitions under Alternative 1 for Training Activities

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions) under Alternative 1, activities involving target materials use would occur throughout the Study Area. All of the ESA-listed species occur where target materials could potentially be expended.

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions), under Alternative 1, activities that expend chaff and flare occur throughout the Study Area. No potential impacts would occur from the chaff itself, but there is some potential for fishes to ingest the end caps, pistons, or compression pads associated with the chaff or flare cartridges.

Environmental concentrations would vary based on release points and dispersion by wind and water currents. The number of end caps and pistons that would remain at or just below the surface in *Sargassum* mats and potentially available to fish is unknown but is expected to be an extremely small percentage of the total.

ESA-listed species in the Key West Range Complex such as smalltooth sawfish and scalloped hammerhead sharks are bottom feeders and would not encounter end caps or flares at the surface, but could ingest an item after it settled to the bottom. However, these items would most likely pass through the digestive tract without causing harm. Based on the low density of expended endcaps and pistons, the encounter rate would be extremely low, and the ingestion rate even lower. No chaff or flares are planned for use in the Northeast Range Complexes where the Atlantic salmon occurs. The number of fishes potentially impacted by ingestion of end caps or pistons would be low based on the low environmental concentration. Population-level effects would not be expected.

As discussed above, it is unlikely that giant manta rays or oceanic whitetip sharks could mistake larger military expended materials other than munitions for prey, even though these species typically forage at or near the surface. If these species accidentally ingested military expended materials other than munitions, it is likely that they would "taste" the item and then spit it out. If these species accidentally ingested an item, it would most likely pass through the digestive tract without causing harm.

Overall, the potential impacts of ingesting decelerators/parachutes, target fragments, or end caps, pistons, or compression pads would be limited to individual fish that ingest an item too large to pass through its gut. Fishes encounter many items (natural and manmade) in their environment that are unsuitable for ingestion and most species have behavioral mechanisms for spitting out the item. If the item were swallowed, it could either pass through the digestive system without doing any harm, or become lodged inside the fish and cause injury or mortality.

For smalltooth sawfish, the likelihood of ingestion of military expended materials other than munitions by early life stages would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep), where no military expended materials would occur. The potential impacts on smalltooth sawfish are discountable because they are historically rare in the locations where military expended materials are expended. Early life stages of sturgeon are typically found in freshwater rivers and not in marine environments, so only juveniles and adults would be potentially exposed to ingestion stressors.

Although ingestion of military expended materials identified here could result in sublethal or lethal effects, the likelihood of ingestion is low based on the dispersed nature of the materials, the limited encounter rate of fishes to the expended items, behavioral mechanisms for expelling the item, and the capacity of the fish's digestive system to simply pass the item through as waste. Based on these factors, the number of fishes potentially impacted by ingestion of military expended materials (such as chaff and flare end caps and pistons) would be low, and no population-level effects would be expected.

Pursuant to the ESA, military expended materials other than munitions from training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Military Expended Materials – Other Than Munitions under Alternative 1 for Testing Activities

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions) under Alternative 1, testing activities involving target materials use would occur throughout the Study Area. All of the ESA-listed species occur where target materials could potentially be expended.

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions), under Alternative 1, activities involving chaff and flare use would occur in offshore locations throughout the Study Area. No potential impacts would occur from the chaff itself, but there is some potential for fishes, including ESA-listed species to ingest the end caps, pistons, or compression pads associated with the chaff or flare cartridges.

The smalltooth sawfish or sturgeon could ingest one of these items after it settled to the bottom, but the item would most likely pass through the digestive tract of a larger fish without causing harm, as the items measure only 1.3 in. (3.3 cm) in diameter and 0.13 in. (0.3 cm) in thickness. Based on the low density of expended end caps and pistons, the encounter rate would be extremely low, and the ingestion rate even lower. The number of fishes potentially impacted by ingestion of end caps or pistons would be low based on the low environmental concentration. Population-level effects would not be expected.

The potential impacts on smalltooth sawfish are discountable because they are historically rare in the locations where decelerators/parachutes, chaff, targets, and end-caps are expended. Smalltooth sawfish are rare in the Gulf of Mexico Large Marine Ecosystem, but since 1999, the species has been documented in the vicinity of the Naval Surface Warfare Center, Panama City Division Testing Range, and a viable population exists off the coast of southwest Florida (Papastamatiou et al., 2015).

For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of ingestion of military expended materials other than munitions by early life stages would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m), where no military expended materials would be expended. Early life stages of sturgeon are typically found in freshwater rivers and not in marine environments, so only juveniles and adults would be potentially exposed to ingestion stressors.

As discussed above, it is unlikely that offshore species such as giant manta rays or oceanic whitetip sharks could mistake larger military expended materials other than munitions for prey during testing activities, even though these species typically forage at or near the surface. It is likely that these species would “taste” and then spit it out if an item were accidentally ingested; if ingested, the item would most likely pass through the digestive tract without causing harm.

Overall, the risk of potential impacts of fishes ingesting military expended materials resulting from proposed testing activities would be low.

Pursuant to the ESA, military expended materials other than munitions from testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.6.2.2 Impacts from Military Expended Materials – Other Than Munitions under Alternative 2

<u>**Impacts from Military Expended Materials – Other Than Munitions under Alternative 2 for Training Activities**</u>

Because training activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials other than munitions under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials other than munitions from training activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Military Expended Materials – Other Than Munitions under Alternative 2 for Testing Activities

Because testing activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials other than munitions under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials other than munitions from testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.6.2.3 Impacts from Military Expended Materials – Other Than Munitions under the No Action Alternative

Impacts from Military Expended Materials – Other Than Munitions under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Ingestion stressors for fishes from military expended materials other than munitions would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.7 Secondary Stressors

This section analyzes potential impacts on fishes exposed to stressors indirectly through impacts on their prey availability and habitat (e.g., sediment or water quality, and physical disturbance). For the purposes of this analysis, indirect impacts on fishes via sediment or water which do not require trophic transfer (e.g., bioaccumulation) in order to be observed are considered here. It is important to note that the terms “indirect” and “secondary” do not imply reduced severity of environmental consequences, but instead describe how the impact may occur in an organism or its ecosystem.

Stressors from Navy training and testing activities could pose secondary or indirect impacts on fishes via habitat (e.g., sediment, and water quality) and prey availability. These include (1) explosives and explosion byproducts; (2) metals; (3) chemicals; and (4) other materials such as targets, chaff, and plastics. Activities associated with these stressors are detailed in Chapter 2 (Description of Proposed Action and Alternatives), and their potential effects are analyzed in Section 3.2 (Sediments and Water Quality), Section 3.4 (Invertebrates), and Section 3.5 (Habitats). The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from explosives and physical disturbance and strike stressors on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources).

This mitigation will consequently help avoid potential impacts on fishes that shelter in and inhabit on shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks.

3.6.3.7.1 Impacts on Habitat

The Proposed Action could result in localized and temporary changes to the benthic community during activities that impact fish habitat. Hard bottom is important habitat for many different species of fish, including those fishes managed by various fishery management plans. Fish habitat could become degraded during activities that would strike the seafloor or introduce military expended materials, bombs, projectiles, missiles, rockets, or fragments to the seafloor. The spatial area of habitat impacted by the Proposed Action would be relatively small compared to the available habitat in the Study Area. However, there would still be vast expanses of habitat adjacent to the areas of habitat impact that would remain undisturbed by the Proposed Action.

Explosions

Secondary impacts to fishes resulting from explosions at the surface, in the water column, or on the bottom would be associated with changes to habitat structure and effects to prey species. Most explosions on the bottom would occur in soft bottom habitat and would displace some amount of sediment, potentially resulting in cratering. However, water movement would redistribute the affected sediment over time. A small amount of sediment would be suspended in the water column temporarily (turbidity), but would resettle to the bottom. Activities that inadvertently result in explosions on or near hard bottom habitat or reefs could break hard structures and reduce the amount of colonizing surface available to encrusting organisms (e.g., corals, sponges). Given the large spatial area of the range complexes compared to the small percentage covered by hard bottom habitat, it is unlikely that most of the small, medium, and large projectiles expended in the Study Area would fall onto this habitat type. Furthermore, these activities are distributed within discrete locations within the Study Area, and the overall footprint of these areas is quite small with respect to the spatial extent of biogenic habitat within the Study Area.

Sinking exercises could also provide secondary impacts on deep-sea populations. These activities occur in open-ocean areas, outside of the coastal range complexes, with potential direct disturbance or strike impacts on deep-sea fishes, as covered in Section 3.6.3.1 (Acoustic Stressors). Secondary impacts on these fishes could occur after the ship hulks sink to the seafloor. Over time, the ship hulk would be colonized by marine organisms that attach to hard surfaces. For fishes that feed on these types of organisms, or whose abundances are limited by available hard structural habitat, the ships that are sunk during sinking exercises could provide an incidental beneficial impact on the fish community (Love & York, 2005; Macreadie et al., 2011).

The alternatives could result in localized and temporary changes to the benthic community during activities that impact fish habitat. Fish habitat could become degraded during activities that would strike the seafloor or introduce military expended materials, bombs, projectiles, missiles, rockets or fragments to the seafloor. During or following activities that impact benthic habitats, fish species may experience loss of available benthic prey at locations in the Study Area where these items might be expended. Additionally, plankton and zooplankton that are eaten by fishes may also be negatively impacted by these same expended materials. The spatial area of habitat impacted by the Proposed Action would be relatively small compared to the available habitat in the Study Area. However, there would still be vast expanses of habitat adjacent to the areas of habitat impact that would remain undisturbed by the Proposed Action.

Impacts of vessel disturbance and strike during amphibious assaults could temporarily reduce the quality and quantity of benthic substrate (sand) over an extremely localized and limited area within Onslow Beach and Seminole Beach. Fishes in the taxonomic group that includes the snapper-grouper complex (as managed by the South Atlantic Fishery Management Council), use these designated amphibious assault areas with sandy benthic substrate as habitat and could be impacted by this activity. However, the secondary habitat impacts on these fishes would be extremely localized compared to the total available area of sandy substrate available in the Jacksonville and Virginia Capes Range Complexes and the overall Study Area.

Impacts of physical disturbance and strikes by small-, medium-, and large-caliber projectiles would be concentrated within designated gunnery box areas, resulting in localized disturbances of hard bottom areas, but could occur anywhere in the range complexes or the Study Area. Hard bottom is important habitat for many different species of fish, including those fishes managed by various fishery management plans. The likelihood these habitats would be impacted is greater in Jacksonville and Navy Cherry Point Range Complexes compared to the Virginia Capes and Key West Range Complexes, based solely on these percentages. However, the location with the smallest proportion of hard bottom habitat (the Virginia Capes Range Complex) has the greatest concentration of small-caliber projectiles expended in the Study Area, with nearly 58 percent of the total small-caliber projectiles expended.

Explosion By-Products

Deposition of undetonated explosive materials into the marine environment can be reasonably well estimated by the known failure and low-order detonation rates of high-explosives. Undetonated explosives associated with munitions disposal and mine clearance are collected after training is complete; therefore, potential impacts are assumed to be inconsequential for these training and testing activities, but other activities could result in unexploded munitions and unconsumed explosives on the seafloor. Fishes may be exposed by contact with the explosive, contact with contaminants in the sediment or water, and ingestion of contaminated sediments.

High-order explosions consume most of the explosive material, creating typical combustion products. In the case of royal demolition explosive, 98 percent of the products are common seawater constituents, and the remainder is rapidly diluted below threshold effect level. Explosion byproducts associated with high order detonations present no indirect stressors to fishes through sediment or water. However, low order detonations and unexploded munitions present elevated likelihood of impacts on fishes.

Indirect impacts of explosives and unexploded munitions to fishes via sediment is possible in the immediate vicinity of the munitions. Degradation of explosives proceeds via several pathways discussed in Section 3.2 (Sediments and Water Quality). Degradation products of royal demolition explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). Trinitrotoluene (TNT) and its degradation products impact developmental processes in fishes and are acutely toxic to adults at concentrations similar to real-world exposures (Halpern et al., 2008b; Rosen & Lotufo, 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 0.15–0.3 m away from degrading munitions, the concentrations of these compounds were not statistically distinguishable from background beyond 1–2 m from the degrading munitions (Section 3.2, Sediments and Water Quality). Taken together, it is likely that various life stages of fishes could be impacted by the indirect impacts of degrading explosives within a very small radius of the explosive (0.3–2 m).

If high-explosive munitions does not explode, it would sink to the bottom. In the unlikely event that explosive material, high-melting-point explosive (known as HMX), or royal demolition explosive (known as RDX) is exposed on the ocean floor, it would break down in a few hours (U.S. Department of the Navy, 2001a). High-melting-point explosive or royal demolition explosive would not accumulate in the tissues of fishes (Lotufo et al., 2010; Price et al., 1998). Fishes may take up trinitrotoluene (TNT) from the water when it is present at high concentrations but not from sediments (Lotufo et al., 2010). The rapid dispersal and dilution of trinitrotoluene (TNT) expected in the marine water column reduces the likelihood of a fish encountering high concentrations of trinitrotoluene (TNT) to near zero.

A series of research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al., 2016; Edwards et al., 2016; Kelley et al., 2016; Koide et al., 2016; University of Hawaii, 2010) and an intensively used live fire range in the Mariana Islands (Smith & Marx, 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life. A summary of this literature which investigated water and sediment quality impacts, on a localized scale, from munitions ocean disposal sites and ocean disposed dredge spoils sites is presented in the Sediment and Water Quality section and specifically in Section 3.2.3.1 (Explosives and Explosives Byproducts) and Section 3.2.3.3 (Metals). Findings from these studies indicate that there were no adverse impacts on the local ecology from the presence of degrading munitions and there was no bioaccumulation of munitions-related chemicals in local marine species. Therefore, water quality effects from the use of munitions, expended material, or devices would be negligible, would have no long-term effect on water quality, and therefore would not constitute a secondary indirect stressor for fishes.

Metals

Certain metals and metal-containing compounds at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) can be toxic to fishes (Wang & Rainbow, 2008). Metals are introduced into seawater and sediments as a result of training and testing activities involving vessel hulks, targets, munitions, batteries, and other military expended materials (Section 3.2, Sediments and Water Quality). Some metals bioaccumulate, and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (U.S. Department of the Navy, 2012). Indirect effects of metals on fish via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Fishes may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Concentrations of metals in seawater are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that fishes would be indirectly impacted by toxic metals via the water.

Chemicals

Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment, principally flares and propellants for rockets, missiles, and torpedoes. Polychlorinated biphenyls are discussed in Section 3.2 (Sediments and Water Quality), but there is no additional risk to fishes because the Proposed Action does not introduce this chemical into the Study Area and the use of polychlorinated biphenyls has been nearly zero since 1979. Properly functioning flares, missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment.

The greatest risk to fishes from flares, missiles, and rocket propellants is perchlorate which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Fishes may be exposed by contact with contaminated water or ingestion of re-suspended contaminated sediments. Since perchlorate is highly soluble, it does not readily adsorb to sediments. Therefore, missile and rocket fuels pose no risk of indirect impact on fishes via sediment. In contrast, the principal toxic components of torpedo fuel, propylene glycol dinitrate, and nitrodiphenylamine, adsorb to sediments, have relatively low toxicity, and are readily degraded by biological processes (Section 3.2, Sediments and Water Quality). It is conceivable that various life stages of fishes could be indirectly impacted by propellants via sediment in the immediate vicinity of the object (e.g., within a few inches), but these potential impacts would diminish rapidly as the propellant degrades.

Other Materials

In some bottom types (without strong currents, hard-packed sediments, and low biological productivity), items such as projectiles might remain intact for some time before becoming degraded or broken down by natural processes. These potential impacts may cease only (1) when the military expended materials are too massive to be mobilized by typical oceanographic processes, (2) if the military expended materials become encrusted by natural processes and incorporated into the seafloor, or (3) when the military expended materials become permanently buried. In this scenario, a parachute could initially sink to the seafloor, but then be transported laterally through the water column or along the seafloor, increasing the opportunity for entanglement. In the unlikely event that a fish would become entangled, injury or mortality could result. In contrast to large decelerators/parachutes, other devices with decelerators such as sonobuoys are typically used in deep open ocean areas. These areas are much lower in fish numbers and diversity, so entanglement hazards are greatly reduced for commercially and recreationally targeted species (i.e., tuna, swordfishes, etc.), as well as mesopelagic prey of other species. The entanglement stressor would eventually cease to pose an entanglement risk as it becomes encrusted or buried.

Pursuant to the ESA, impacts on habitat from secondary stressors during training and testing activities, as described above, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.7.2 Impacts on Prey Availability

Impacts on fish prey availability resulting from explosives, explosives byproducts, unexploded munitions, metals, and chemicals would differ depending upon the type of prey species in the area, but would likely be negligible overall and have no population-level impacts on fishes. As discussed in Section 3.6.3.1 (Acoustic Stressors), fishes with swim bladders are more susceptible to blast injuries than fishes without swim bladders. During or following activities that impact benthic habitats, fish species may experience loss of available benthic prey at locations in the Study Area where these items might be expended. Additionally, plankton and zooplankton that are eaten by fishes may also be negatively impacted by these same expended materials some species of zooplankton that occur in the Pacific such as Pacific oyster (*Crassostrea gigas*) larvae have been found feeding on microplastics (Cole & Galloway, 2015).

In addition to physical effects of an underwater blast such as being stunned, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to detonations that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Mather, 2004). The sound from underwater explosions might induce startle reactions and temporary dispersal of schooling fish if they are within close proximity (Popper et al., 2014; Wright, 1982).

The abundances of fish and invertebrate prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. The sound from underwater explosions might induce startle reactions and temporary dispersal of schooling fishes, potentially increasing visibility to predators, if they are within close proximity (Kastelein et al., 2008). Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting impact on prey availability or the food web would be expected. Indirect impacts of underwater detonations and high explosive munitions use under the Proposed Action would not result in a decrease in the quantity or quality of fish populations in the Study Area.

Pursuant to the ESA, impacts on prey availability from secondary stressors during training and testing activities, as described above, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.4 Summary of Potential Impacts on Fishes

3.6.4.1 Combined Impacts of All Stressors under Alternative 1

As described in Section 3.0.3.5 (Resource-Specific Impacts Analysis for Multiple Stressors), this section evaluates the potential for combined impacts of all the stressors from the Proposed Action. The analysis and conclusions for the potential impacts from each individual stressor are discussed in the analyses of each stressor in the sections above and summarized in Section 3.6.5 (Endangered Species Act Determinations).

There are generally two ways that a fish could be exposed to multiple stressors. The first would be if a fish were exposed to multiple sources of stress from a single activity (e.g., a mine warfare activity may include the use of a sound source and a vessel). The potential for a combination of these impacts from a single activity would depend on the range of effects of each stressor and the response or lack of response to that stressor. Most of the activities as described in the Proposed Action involve multiple stressors; therefore, it is likely that if a fish were within the potential impact range of those activities, it may be impacted by multiple stressors simultaneously. This would be even more likely to occur during large-scale exercises or activities that span a period of days or weeks (such as a sinking exercises or composite training unit exercise).

A fish could also be exposed to a combination of stressors from multiple activities over the course of its life. This is most likely to occur in areas where training and testing activities are more concentrated (e.g., near naval ports, testing ranges, and routine activity locations and in areas that individual fish frequent because it is within the animal's home range, migratory corridor, spawning or feeding area. Except for in the few concentration areas mentioned above, combinations are unlikely to occur because training and testing activities are generally separated in space and time in such a way that it would be very unlikely that any individual fish would be exposed to stressors from multiple activities. However, animals with a home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory corridor. The majority of the proposed training and testing activities occur over a small spatial scale relative to the entire Study Area, have few participants, and are of a short duration (on the order of a few hours or less).

Multiple stressors may also have synergistic effects. For example, fishes that experience temporary hearing loss or injury from acoustic stressors could be more susceptible to physical strike and disturbance stressors via a decreased ability to detect and avoid threats. Fishes that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to entanglement and physical strike stressors via malnourishment and disorientation. These interactions are speculative, and without data on the combination of multiple Navy stressors, the synergistic impacts from the combination of Navy stressors are difficult to predict in any meaningful way. Navy research and monitoring efforts include data collection through conducting long-term studies in areas of Navy activity, occurrence surveys over large geographic areas, biopsy of animals occurring in areas of Navy activity, and tagging studies where animals are exposed to Navy stressors. These efforts are intended to contribute to the overall understanding of what impacts may be occurring overall to animals in these areas.

The combined impacts under Alternative 1 of all stressors would not be expected to impact fish populations because (1) activities involving more than one stressor are generally short in duration, and (2) such activities are dispersed throughout the Study Area. Existing conditions would not change considerably, therefore, no impacts on fish populations would occur with the implementation of Alternative 1.

3.6.4.2 Combined Impacts of All Stressors under Alternative 2

The combined impacts under Alternative 2 of all stressors would not be expected to impact fish populations because (1) activities involving more than one stressor are generally short in duration, and (2) such activities are dispersed throughout the Study Area. Existing conditions would not change considerably, therefore, no impacts on fish populations would occur after the implementation of Alternative 2.

3.6.4.3 Combined Impacts of All Stressors under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. The combined impacts of all stressors for fishes would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities and no impacts on fish population would occur.

3.6.5 ENDANGERED SPECIES ACT DETERMINATIONS

Pursuant to the ESA, the Navy has concluded training and testing activities may affect the Atlantic salmon, Atlantic sturgeon, giant manta ray, gulf sturgeon, Nassau grouper, oceanic whitetip shark, scalloped hammerhead shark, shortnose sturgeon, and smalltooth sawfish. The Navy has also concluded that training and testing activities may affect designated critical habitat for the Atlantic sturgeon and gulf sturgeon; and have no effect on designated critical habitat for the Atlantic salmon and smalltooth sawfish. The Navy has consulted with NMFS as required by section 7(a)(2) of the ESA in that regard. The Navy's summary of effects determinations for each ESA-listed species is shown in Table 3.6-18. Where the effects determinations reached by NMFS in their Biological Opinion differed from the Navy's, those differences are noted in a footnote to Table 3.6-18. NMFS determinations are made on the overall Proposed Action and are not separated by training and testing activities.

Table 3.6-18: Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Training Activities																			
Atlantic salmon	Gulf of Maine DPS	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NE	NE	NLAA	NLAA	NLAA	NE	NLAA	NLAA	N/A	NLAA	NLAA
	Critical habitat	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	N/A	NE	NE
Atlantic sturgeon	Gulf of Maine DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
	New York Bight DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
	Chesapeake Bay DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	LAA	LAA	NLAA	NLAA	NLAA	LAA[1]	N/A	LAA[1]	LAA[1]
	Carolina DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	LAA	LAA	NLAA	NLAA	NLAA	LAA[1]	N/A	LAA[1]	LAA[1]
	South Atlantic DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
	Critical habitat	NE[1]	N/A	NE	NE[1]	NE	NE	NE	NE	NE	NE[1]	NE[1]	NE[1]	NLAA	NE	NE	N/A	NE	NE
Giant manta ray	Throughout range	NLAA	N/A	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
Gulf sturgeon	Throughout range	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NLAA	NE	LAA	LAA[1]	NLAA	NLAA	NLAA	NLAA	N/A	NLAA	NLAA
	Critical habitat	NE	N/A	NE	NE	NE	NE	NLAA	NE	NE	NE	NE	NE	NLAA	NE	NE	N/A	NE	NE

Table 3.6-18. Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative) (continued)

		Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
Species	Designation Unit	Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Training Activities (continued)																			
Nassau grouper	Throughout range	NLAA	N/A	NE	NLAA	NE[1]	NE[1]	NLAA	NE	NE	NE[1]	NE[1]	NLAA	NLAA	NE	NLAA	N/A	NLAA	NLAA
Oceanic whitetip shark	Throughout range	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	N/A	NLAA	NLAA
Scalloped hammerhead shark	Central and Southwest Atlantic DPS	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NE	NE	NLAA	NLAA	NLAA	NLAA	NE	NLAA	N/A	NLAA	NLAA
Shortnose sturgeon	Throughout range	NLAA	N/A	NLAA	NLAA	NLAA	NE[1]	NLAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	N/A	LAA[1]	LAA[1]
Smalltooth sawfish	U.S. DPS	NLAA	N/A	NE	NLAA	NLAA	NE[1]	LAA	NLAA	NE[1]	NE	NE[1]	NLAA	NLAA	NLAA	NLAA	N/A	NLAA	NLAA
	Critical habitat	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	N/A	NE	NE
Testing Activities																			
Atlantic salmon	Gulf of Maine DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE[1]	NLAA	NLAA
	Critical habitat	NE	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Table 3.6-18. Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative) (continued)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Testing Activities (continued)																			
Atlantic sturgeon	Gulf of Maine DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	New York Bight DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	Chesapeake Bay DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	Carolina DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	South Atlantic DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	Critical habitat	NE[1]	NE	N/A	NE[1]	NE	NE	NE	NE	NE	NE[1]	NE[1]	NE[1]	NE[1]	NE	NE	NE	NE	NE
Giant manta ray	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
Gulf sturgeon	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
	Critical habitat	NE	NE	N/A	NE	NE	NE	NLAA	NE	NE	NE	NE	NE	NLAA	NE	NE	NE	NE	NE
Nassau grouper	Throughout range	NLAA	NE	N/A	NLAA	NE[1]	NE[1]	NLAA	NLAA	NE[1]	NE[1]	NE[1]	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA

Table 3.6-18. Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative) (continued)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Testing Activities (continued)																			
Oceanic whitetip shark	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Scalloped hammerhead shark	Central and Southwest Atlantic DPS	NLAA	NE	N/A	NLAA	NLAA	NLAA	LAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Shortnose sturgeon	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NE[1]	NLAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Smalltooth sawfish	U.S. DPS	NLAA	NLAA	N/A	NLAA	NLAA	NE[1]	LAA	NLAA	NE[1]	NE	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
	Critical habitat	NE	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Note: DPS= Distinct Population Segment; NE = no effect; NLAA = may effect, not likely to adversely affect; LAA = may effect, likely to adversely affect; N/A = not applicable, activity related to the stressor does not occur during specified training or testing events (e.g., there are no testing activities that involve the use of pile driving).
[1] Based on the analysis conducted in the Biological Opinion, NMFS reached the determination of NLAA.
[2] Based on the analysis conducted in the Biological Opinion, NMFS reached the determination of LAA.

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