

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

Title: Biological and Conference Opinion on (1) U.S. Navy and U.S. Coast Guard Atlantic Fleet Training and Testing and (2) the National Marine Fisheries Service's Promulgation of Regulations and Issuance of Letters of Authorization Pursuant to the Marine Mammal Protection Act for the Navy and Coast Guard to "Take" Marine Mammals Incidental to Atlantic Fleet Training and Testing Through November 2032

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Action Agencies: U.S. Department of the Navy; U.S. Coast Guard; and Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Publisher: Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Approved: DAMON
RANDALL.KIMBERLY.BETH.136582
H.1365821093

Digitally signed by DAMON
RANDALL.KIMBERLY.BETH.136582
1093
Date: 2025.09.02 12:42:44 -04'00'

Kim Damon-Randall
Director, Office of Protected Resources

Date: 09/02/2025

Consultation Tracking number: OPR-2024-02209

Digital Object Identifier (DOI): <https://doi.org/10.25923/xrjs-1546>

This page left blank intentionally

TABLE OF CONTENTS

	Page
1 Introduction.....	14
1.1 Background	16
1.2 Consultation History	18
1.3 Analytical Approach	21
2 Description of the Proposed Action.....	24
2.1 Primary Mission Areas.....	25
2.2 Proposed Military Readiness Activities	28
2.2.1 Training Activities	28
2.2.2 Testing Activities	30
2.2.3 Foreign Military Activities	31
2.3 Standard Operating Procedures and Mitigation Measures	32
2.3.1 Standard Operating Procedures.....	32
2.3.2 Mitigation Measures	36
2.4 Stressors Resulting from the Components of the Proposed Action	70
2.4.1 Acoustic Stressors	71
2.4.2 Explosive Stressors	82
2.4.3 Energy Stressors.....	85
2.4.4 Physical Disturbance and Strike Stressors	86
2.4.5 Entanglement Stressors	90
2.4.6 Ingestion Stressors	92
2.4.7 Other Stressors	94
2.5 MMPA Regulations and Issuance of Letters of Authorization.....	94
3 Action Area	95
4 Species and Designated Critical Habitat that May be Affected.....	98
4.1 May Affect, Not Likely to be Adversely Affected.....	100
4.1.1 Stressors Not Likely to Adversely Affect ESA-listed Species	101
4.1.2 Species Not Likely to be Adversely Affected.....	153
4.1.3 Critical Habitat Not Likely to be Adversely Affected	156
4.2 Status of the Species Likely to be Adversely Affected.....	190
4.2.1 Blue Whale.....	191
4.2.2 Fin Whale.....	196
4.2.3 Rice’s Whale.....	200
4.2.4 North Atlantic Right Whale	206
4.2.5 Sei Whale	216
4.2.6 Sperm Whale.....	219
4.2.7 Green Sea Turtle – North Atlantic DPS.....	223
4.2.8 Hawksbill Turtle	227

4.2.9	Kemp’s Ridley Turtle	230
4.2.10	Leatherback Sea Turtle	233
4.2.11	Loggerhead Sea Turtle – Northwest Atlantic Ocean DPS	238
4.2.12	Atlantic Salmon – Gulf of Maine DPS	243
4.2.13	Atlantic Sturgeon	248
4.2.14	Giant Manta Ray	265
4.2.15	Gulf Sturgeon	270
4.2.16	Oceanic Whitetip Shark	274
4.2.17	Scalloped Hammerhead Shark – Central and Southwest Atlantic DPS	280
4.2.18	Smalltooth Sawfish – United States Portion of Range DPS	285
4.2.19	Corals – General Threats	289
4.2.20	Elkhorn Coral	292
4.2.21	Staghorn Coral	298
4.2.22	Pillar Coral	302
4.2.23	Rough Cactus Coral	308
4.2.24	Lobed Star, Mountainous Star, and Boulder Star Coral	311
4.2.25	Queen Conch	322
5	Environmental Baseline	326
5.1	Large-Scale Changes in Environmental Conditions	326
5.2	Anthropogenic Sound	333
5.2.1	Vessel Sound and Commercial Shipping	335
5.2.2	Seismic Surveys	336
5.2.3	Active Sonar	338
5.2.4	Pile Driving and Construction Sound	338
5.2.5	Oil and Gas	339
5.2.6	Oil Spills and Natural Seeps	340
5.3	Dredging	343
5.4	Pollution	344
5.4.1	Contaminants and Pesticides	344
5.4.2	Nutrient Loading and Algal Blooms	348
5.4.3	Marine Debris	349
5.5	Offshore Wind Development	351
5.6	Fisheries Directed Harvest and Bycatch	352
5.6.1	Federally Managed Fisheries	354
5.6.2	State Managed Fisheries	358
5.7	Fishery Interactions and Entanglement	359
5.8	Historical Whaling	360
5.9	Aquaculture	361
5.10	Vessel Strike	361
5.10.1	Marine Mammals	362

5.10.2	Sea Turtles	364
5.10.3	Sturgeon	365
5.11	Invasive Species	367
5.12	Diseases and Parasites	369
5.13	Scientific Research and Permits	371
5.14	Ongoing Military Readiness Activities	373
5.15	The Impact of the Environmental Baseline on ESA-Listed Resources	374
6	Analysis of Effects	374
6.1	Marine Mammals	375
6.1.1	Acoustic and Explosive Effects Analysis	375
6.1.2	Vessel Strike Analysis	420
6.2	Sea Turtles	441
6.2.1	Acoustic and Explosive Effects Analysis	441
6.2.2	Vessel Strike Analysis	454
6.3	Fishes	464
6.3.1	Acoustic and Explosives Effects Analysis	464
6.3.2	Vessel Strikes	484
6.4	Invertebrates	494
6.4.1	Acoustic Effects Analysis	494
6.4.2	Explosives	496
6.5	Summary of Effects Determinations	509
7	Cumulative Effects	514
8	Integration and Synthesis	514
8.1	Jeopardy Analysis	515
8.1.1	North Atlantic Right Whale	515
8.1.2	Blue Whale	520
8.1.3	Fin Whale	522
8.1.4	Sei Whale	525
8.1.5	Rice’s Whale	527
8.1.6	Sperm Whale	529
8.1.7	Green Sea Turtle – North Atlantic DPS	532
8.1.8	Hawksbill Sea Turtle	534
8.1.9	Kemp’s Ridley Sea Turtle	536
8.1.10	Loggerhead Sea Turtle – Northwest Atlantic DPS	538
8.1.11	Leatherback Sea Turtle	541
8.1.12	Atlantic Salmon – Gulf of Maine DPS	543
8.1.13	Atlantic Sturgeon	545
8.1.14	Giant Manta Ray	547
8.1.15	Oceanic Whitetip Shark	550

8.1.16	Gulf Sturgeon.....	552
8.1.17	Scalloped Hammerhead Shark – Central and Southwest Atlantic DPS	554
8.1.18	Smalltooth Sawfish	556
8.1.19	ESA-listed Coral Species.....	558
8.1.20	Queen Conch.....	561
9	Conclusion	563
10	Incidental Take Statement	563
10.1	Amount or Extent of Take.....	564
10.1.1	Marine Mammals and Sea Turtles	564
10.1.2	Fish.....	567
10.1.3	Invertebrates.....	569
10.2	Reasonable and Prudent Measures	570
10.3	Terms and Conditions	571
11	Conservation Recommendations	573
12	Reinitiation Notice	574
13	References	575

LIST OF TABLES

	Page
Table 1. Primary Mission Areas and Associated AFTT Activities (Navy 2024c)	25
Table 2. Major Training Exercises and Integrated/Coordinated Training Activities Included in the Proposed Action (Navy 2025a).....	29
Table 3. AFTT Training Activities Typically not Conducted within the Coastal Zone (Navy 2024c)	35
Table 4. AFTT Testing Activities Typically not Conducted within the Coastal Zone (Navy 2024c)	36
Table 5. Activity-based Mitigation for Acoustic Stressors.....	41
Table 6. Activity-based Mitigation for Explosive Stressors	42
Table 7. Activity-based Mitigation for Non-Explosive Ordnance.....	50
Table 8. Activity-based Mitigation for Vessels, Vehicles, and Towed In-Water Devices.....	52
Table 9. Shallow-Water Coral Reef Mitigation Area (Navy 2024c)	55
Table 10. Artificial Reef, Live Hard Bottom, Submerged Aquatic Vegetation, and Shipwreck Mitigation Area (Navy 2024c).....	55
Table 11. Key West Range Complex Seafloor Mitigation Area (Navy 2024c)	56
Table 12. South Florida Ocean Measurement Facility Seafloor Mitigation Area (Navy 2024c)	56
Table 13. Nearshore North Carolina Sandbar Shark and Sea Turtle Mitigation Area (Navy 2024c).....	58
Table 14. Panama City Gulf Sturgeon and Sea Turtle Mitigation Area (Navy 2024c)	58
Table 15. Inshore Manatee and Sea Turtle Mitigation Area (Navy 2024c).....	58
Table 16. Ship Shock Trial Mitigation Area (Navy 2024c).....	60
Table 17. Major Training Exercise Planning Awareness Mitigation Area (Navy 2024c)	60
Table 18. Northeast North Atlantic Right Whale Mitigation Area (Navy 2024c).....	62
Table 19. Gulf of Maine Marine Mammal Mitigation Area (Navy 2024c).....	65
Table 20. Jacksonville Operating Area North Atlantic Right Whale Mitigation Area (Navy 2024c).....	65

Table 21. Southeast North Atlantic Right Whale Mitigation Area (Navy 2024c).....	66
Table 22. Southeast North Atlantic Right Whale Special Reporting Mitigation Area (Navy 2024c).....	67
Table 23. Dynamic North Atlantic Right Whale Mitigation Area (Navy 2024c)	67
Table 24. Rice’s Whale Mitigation Area (Navy 2024c)	68
Table 25. Demolition Key Queen Conch Mitigation Area	70
Table 26. Sound Characteristics of Representative Aircraft Proposed for AFTT	73
Table 27. Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight (Navy 2017).....	75
Table 28. Sonar and Transducer Source Categories and Activity Levels (Navy 2024c)	77
Table 29. Examples of Noise from Weapons (Navy 2024c)	79
Table 30. Number of Shots from Air Guns and Non-explosive Sources Proposed for Use in the Action Area (Navy 2024c).....	81
Table 31. Number of Piles / Sheets Proposed During Pile Driving and Removal Training Activities (Navy 2024c)	81
Table 32. Port Damage Repair Training Pile Driving and Removal Underwater Sound Levels (Navy 2024c).....	82
Table 33. Number of Explosives within Each Bin that Could Occur in Any Year (and over 7-years) for AFTT Phase IV Military Readiness Activities (Navy 2024c)	83
Table 34. Typical Air Explosive Munitions Proposed for AFTT Phase IV (Navy 2024c)	85
Table 35. Representative Vessel Types, Lengths, and Speeds (Navy 2024c)	87
Table 36. Representative Types, Sizes, and Speeds of In-Water Devices (Navy 2024c)	90
Table 37. Size Categories for Decelerators and Parachutes Expended During Training and Testing Activities (Navy 2024c)	92
Table 38. Training and Testing Ranges included in the AFTT Action Area (Navy 2024c)	97
Table 39. Inshore Waters Included in the AFTT Action Area	98

Table 40. ESA-listed Species and Designated or Proposed Critical Habitat that May Be Affected by the Proposed Action with Listing Status and Recovery Plan Information	99
Table 41. Pile Driving Range to Effects for Sea Turtles (Navy 2024c)	116
Table 42. Sound Exposure Criteria for Pile Driving (Navy 2024c)	118
Table 43. Impact Ranges for Resident Fishes from Impact Pile Driving (one day) (Navy 2024c)	118
Table 44. Physical and Biological Features within each Critical Habitat Unit for the Northwest Atlantic Ocean DPS of Loggerhead Sea Turtle.....	166
Table 45. Calculated Atlantic Sturgeon Population Estimates Based upon the NEAMAP Survey Swept Area Model, Assuming 50% Efficiency	250
Table 46. Estimated Abundance of Spawning Runs in the Pamunkey River, the Primary Spawning Tributary of the York River	259
Table 47. Available Estimates of Effective Population Sizes in the Rivers of the South Atlantic DPS	262
Table 48. Average Annual Exempted Take of Sea Turtles and Atlantic Sturgeon over a 5-Year Period as a Result of the 2021 Biological Opinion and ITS on the American Lobster, Atlantic Bluefish, Atlantic Deep-Sea Red Crab, Mackerel/Squid/Butterfish, Monkfish, Northeast Multispecies, Northeast Skate Complex, Spiny Dogfish, Summer Flounder/Scup/Black Sea Bass, and Jonah Crab fisheries (NMFS 2021b).....	354
Table 49. Exempted Take for Sea Turtles from all other Current Section 7 Fisheries Consultations on the U.S. Atlantic Coast	355
Table 50. Estimated Average Annual Sea Turtle Interactions in Select Commercial Fishing Gears in the Mid-Atlantic and Georges Bank Regions (numbers in parentheses are adult equivalents)	356
Table 51. Programmatic Mortality Bank Limits and Takes of Sea Turtles in the Atlantic Ocean and Gulf of America. Bank Limits and Takes are Authorized over 10 years (2018-2027) (NMFS 2024a).....	371
Table 52. Comparison of Phase III and Phase IV Mortality and Injury Thresholds	379
Table 53. Summary of Phase IV TTS/AINJ Thresholds (SEL thresholds are in dB re 1 μ Pa _{2s} underwater)	383
Table 54. Estimated Abundances of ESA-Listed Stocks Present in the AFTT Action Area (Navy 2024e).....	388

Table 55. Estimated Acoustic and Explosive Effects to North Atlantic Right Whales over a Maximum Year of Proposed Activities (Navy 2024a)	389
Table 56. Estimated Acoustic and Explosive Effects to the Rice's Whale over a Maximum Year of Proposed Activities (Navy 2024a)	391
Table 57. Estimated Acoustic and Explosive Effects to Blue Whales over a Maximum Year of Proposed Activities (Navy 2024a)	392
Table 58. Estimated Acoustic and Explosive Effects to Fin Whales over a Maximum Year of Proposed Activities (Navy 2024a)	393
Table 59. Estimated Acoustic and Explosive Effects to Sei Whales over a Maximum Year of Proposed Activities (Navy 2024a)	394
Table 60. Estimated Acoustic and Explosive Effects to the North Atlantic Stock of Sperm Whales over a Maximum Year of Proposed Activities (Navy 2024a).....	395
Table 61. Estimated Acoustic and Explosive Effects to the Gulf of Mexico Stock of Sperm Whales over a Maximum Year of Proposed Activities (Navy 2024a).....	396
Table 62. Annual Rates of M/SI for Large Whale Species (or DPSs) from Vessel Strikes in the Atlantic Ocean and Gulf of America from 2017 to 2021 (unless otherwise noted), and Relative Probability of Striking each Large Whale Species or DPS During that Time Period (Hayes et al. 2023)	434
Table 63. Comparison of Phase III and Phase IV Sea Turtle TTS and AINJ Onset Levels for Non-impulsive (sonar) and Impulsive (explosives, airguns) Sound Sources (weighted SEL onset units are dB re 1 μ Pa ² s; impulsive peak SPL onsets units are dB re 1 μ Pa	443
Table 64. Estimated Acoustic and Explosive Effects to North Atlantic DPS Green Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)	447
Table 65. Estimated Acoustic and Explosive Effects to Kemp's Ridley Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)	449
Table 66. Estimated Acoustic and Explosive Effects to Leatherback Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)	449
Table 67. Estimated Acoustic and Explosive Effects to Northwest Atlantic DPS of Loggerhead Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)	450
Table 68. Estimated AFTT Annual High Speed (i.e., greater than 10 knots) Vessel Hours for Small Craft in Inshore Locations by Range Complex (Navy 2024c).....	458
Table 69. Estimated Sex Ratios of Sea Turtle Vessel Strikes as a Result of the Proposed Action, based on STSSN Strandings Database Records from 2014-2023.....	464

Table 70. Location and Days of Airgun Operations within AFTT (Navy 2024c).....	470
Table 71. Ranges to Effects to Fish from AFTT Explosives by Bin, Hearing Group, Depth, and Cluster Size (Navy 2025b)	478
Table 72. Atlantic Sturgeon DPS Proportional Distributions by Region (based on Kazyak et al. 2021), and Estimated Vessel or USV Strikes by DPS as a Result of the Proposed Action	493
Table 73. Summary of Estimated ESA-listed Coral Mortality Resulting from AFTT Explosive Activities	507
Table 74. NMFS ESA effects determinations by stressor for each ESA-listed species and critical habitat, and overall effects determination for each species and critical habitat (LAA = likely to adversely affect; NLA = not likely to adversely affect; NE = no effect)	509
Table 75. Known Geographic Distribution and Abundance of ESA-listed Corals in the Action Area.	559
Table 76. Number and Type of ESA Takes of Marine Mammals and Sea Turtles Anticipated to Occur Over a Maximum Year of Activities from Acoustic and Explosive Stressors, and Over Every Seven Years from Vessel Strike, as a Result of AFTT Military Readiness Activities.	565
Table 77. Number and Type of ESA Takes of Marine Mammals and Sea Turtles Anticipated to Occur Over Every Seven Years from Acoustic and Explosive Stressors as a Result of AFTT Military Readiness Activities.....	567
Table 78. Number of Lethal Takes of ESA-listed Sturgeon, by Species or DPS, Anticipated to Occur from Vessel or USV Strike as a Result of AFTT Military Readiness Activities.....	568

LIST OF FIGURES

	Page
Figure 1. AFTT Geographic Mitigation Areas	54
Figure 2. Relative Distribution of Navy Vessel Traffic in the Atlantic Coast Portion of the Action Area (Mintz 2016).....	72
Figure 3. Proposed Locations and Annual Number of Propulsion Testing Events within the AFTT Action Area (Navy 2024a).....	87
Figure 4. AFTT Action Area (Navy 2024c)	96
Figure 5. Aerial Target with Deployed Parachute (Navy 2017).....	137
Figure 6. North Atlantic Right Whale Critical Habitat.....	156
Figure 7. Area of Proposed Critical Habitat for the Rice's Whale in the Gulf of America.....	159
Figure 8. Overlap between Proposed Rice's Whale Critical Habitat and the Navy's Panama City Testing Range, Panama City OPAREA and Pensacola OPAREA	163
Figure 9. 100 Hz and 150 Hz Ambient Sound Pressure Spectrum Levels at LISTEN GoMex Sites from 2020-2022 (Frasier et al. 2024b)	164
Figure 10. Designated Critical Habitat for the Northwest Atlantic Ocean DPS of Loggerhead Sea Turtles.	165
Figure 11. Proposed Marine Critical Habitat for the Green Sea Turtle North Atlantic DPS	169
Figure 12. Map Showing the 31 Coastal Rivers Designated as Critical Habitat for Atlantic Sturgeon	173
Figure 13. Nassau Grouper Critical Habitat South Florida.....	177
Figure 14. Nassau Grouper Critical Habitat Puerto Rico and US Virgin Islands.....	177
Figure 15. Designated Critical Habitat for Nassau Grouper within the AFTT Action Area.....	178
Figure 16. Map of Gulf Sturgeon Designated Critical Habitat in the Gulf of America (NOAA 2007).....	179
Figure 17. Map Identifying Critical Habitat for Threatened and Endangered Atlantic/Caribbean Corals off Florida	183
Figure 18. Map Identifying Critical Habitat for Threatened and Endangered Atlantic/Caribbean Corals off Puerto Rico and United States Virgin Islands	184

Figure 19. Map Identifying Critical Habitat for Elkhorn and Staghorn Corals off Florida	187
Figure 20. Map Identifying Critical Habitat for Elkhorn and Staghorn Corals off Puerto Rico and United States Virgin Islands.....	188
Figure 21. Distribution of Blue Whale Sightings off the Atlantic Coast from Shipboard (circles) and Aerial (squares) Summer Surveys between 1998 and 2016 (Hayes et al. 2020)	193
Figure 22. Distribution of Sightings and Strandings of Bryde's-like Whales in the Gulf of America and Atlantic U.S. EEZ from 1992 to 2019 (Rosel et al. 2021).....	202
Figure 23. Predicted Average Rice's Whale Density (whales per 40 km ² , grid cell area) (Garrison et al. 2024b)	203
Figure 24. Seasonal Rice's Whale Predicted Density (whales per 40 km ² , grid cell area) Reflecting Average Environmental Conditions in each Season from 2015–2019 (Garrison et al. 2024b)	204
Figure 25. Approximate Range (shaded area) and Distribution of Sightings (dots) of Known North Atlantic Right Whales (Hayes et al. 2023).....	207
Figure 26. Schematic of the 2017-2025 North Atlantic Right Whale UME Showing the Number of Whales Killed, Seriously Injured, and Injured/Poor Health (through April 9, 2025), and the Likely Cause of Injury or Death (NMFS 2025b)	211
Figure 27. Distribution of Sperm Whale Sightings from Shipboard (circles) and Aerial (squares) Summer Surveys between 1998 and 2016 (Hayes et al. 2020).....	221
Figure 28. Geographic Range of the North Atlantic DPS of Green Turtles, with Location and Abundance of Nesting Females (Seminoff et al. 2015).....	224
Figure 29. Map Identifying the Range of the Endangered Hawksbill Sea Turtle.....	228
Figure 30. Map Identifying the Range of the Endangered Kemp's Ridley Sea Turtle.....	231
Figure 31. Leatherback Sea Turtle DPS Boundary Map (NMFS and USFWS 2020b)	234
Figure 32. Northwest Atlantic Ocean DPS of Loggerhead Sea Turtle Range.....	239
Figure 33. Gulf of Maine DPS for Atlantic Salmon with the Three Recovery Units Identified (Kennebec River Watershed is shown in green)	244
Figure 34. Life Cycle of the Atlantic salmon (diagrams courtesy of Katrina Mueller).....	245

Figure 35. Range and Boundaries of the Five Atlantic Sturgeon DPSs.	249
Figure 36. Extent of Occurrence (dark blue) and Area of Occupancy (light blue) for Giant Manta Rays based on Species Distribution (Lawson et al. 2017)	265
Figure 37. Geographic Range and Designated Critical Habitat of the Gulf Sturgeon	271
Figure 38. Geographic Range of the Oceanic Whitetip Shark.....	275
Figure 39. Estimated Change in Relative Abundance (standardized catch per 1,000 hooks) between 1992 and 2019 based on the Northwest Atlantic Pelagic Longline Observer Data for Oceanic Whitetip Sharks (Source: NMFS Observer Database).....	278
Figure 40. Range and DPS Delineation for the Scalloped Hammerhead Shark.....	281
Figure 41. Relative Global Density of Scalloped Hammerhead Sharks (Queiroz et al. 2019)	283
Figure 42. Map Depicting the Range and Designated Critical Habitat for the U. S. DPS of Smalltooth Sawfish	286
Figure 43. Range Map for Elkhorn and Staghorn Coral	293
Figure 44. Range Map for Pillar Coral	303
Figure 45. Status of Known Pillar Coral Colonies in Florida between 2014 and 2020 (Neely et al. 2021).....	305
Figure 46. Condition of Known Pillar Coral Colonies in Florida between 2014 and 2017 (Figure courtesy of K. Neely, Nova Southeastern University, and C. Lewis, Florida International University).....	306
Figure 47. Range Map for Rough Cactus Coral	309
Figure 48. Range Map for Lobed, Mountainous, and Boulder Star Corals	311
Figure 49. Map of the Geographic Distribution of Queen Conch	322
Figure 50. Global Annual Average Temperature (a) Yearly Surface Temperature Compared to the 20th Century Average from 1880-2022 (NOAA climate.gov)	327
Figure 51. Relative Distribution of Nonmilitary Vessel Traffic (> 65 ft in length) in the AFTT Action Area (Navy 2025a).....	336
Figure 52. Map of the Gulf of America Showing the Location of the Deepwater Horizon Oil Rig and the Area Affected by the Oil Spill (Marques et al. 2023)	341
Figure 53. Documented Ship Strikes of Atlantic Sturgeon between 2007 and 2016 (Balazik 2016).....	366

Figure 54. Navy Phase IV Weighting Functions by Species Group (amplitude in dB on y-axis; frequency in kHz on x-axis)	381
Figure 55. Comparison of Navy Phase IV TTS Exposure Functions for Sonars and Other Non-impulsive Active Acoustic Sources across Species Groups (exposure SEL in dB on y-axis; frequency in kHz on x-axis).....	382
Figure 56. Comparison of Navy Phase IV TTS Exposure Functions for Explosives, Impact Pile Driving, Air Guns, and Other Impulsive Acoustic Sources Across Species Groups (exposure SEL in dB on y-axis; frequency in kHz on x-axis).....	382
Figure 57. Phase IV Mysticete Biphasic Behavioral Response Function (50% credible interval shaded in teal)	385
Figure 58. Phase IV Odontocete Biphasic Behavioral Response Function (50% credible interval shaded in teal)	385
Figure 59. Intrinsic and Extrinsic Factors to Consider when Assessing Likely Consequences to Individuals and Marine Mammal Populations from Anthropogenic Stressors (Keen et al. 2021)	417
Figure 60. Comparison of Phase III (thin gray lines) and Phase IV (thick black lines) Sea Turtle Composite Audiograms (Navy 2025c).....	444
Figure 61. Comparison of Phase III (thin gray lines) and Phase IV (thick black lines) Sea Turtle Exposure Functions for Non-impulsive TTS (solid lines) and AINJ (dashed lines) (Navy 2025c)	444
Figure 62. Hearing Frequency Ranges (pressure) of Some ESA-listed Fish Groups Compared to Navy Defined Sonar Classes. Sources: (Tavolga and Wodinsky 1963; Hawkins and Johnstone 1978; Popper et al. 2007; Popper 2008; Popper et al. 2014).	466
Figure 63. Injury Rates for Severe Injury (a) and Any Injury (b) of Pacific Mackerel Exposed to Explosive Detonations at Varying Sound Pressure Levels (Bowman et al. 2024).....	474
Figure 64. Major Current Systems in the Portion of the Action Area within the Range of ESA-listed Corals (Lee et al. 1992).....	498
Figure 65. Distribution of Known Shallow-water Coral Reefs and Hard Substrate Suitable for Shallow-water Coral Reef Species (< 90 m deep) in the South Florida Portion of the Action Area.....	500
Figure 66. Prediction of Distance to 90% Survivability of Marine Invertebrates Exposed to an Underwater Explosion (Young 1991)	508

1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. §1531 et seq.) establishes a national mandate for conserving threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. Section 7(a)(2) of the Act and its implementing regulations require every Federal agency, in consultation with and with the assistance of the Secretary (as defined in 16 U.S.C. §1532(15)), to insure that any action it authorizes, funds, or carries out, in whole or in part, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or results in the destruction or adverse modification of critical habitat. Federal agencies must consult with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction at 50 CFR §223.102(e) and 224.101(h).

Section 7(a)(4) of the ESA requires Federal agencies to confer with the Secretary on any action that is likely to jeopardize the continued existence of proposed species or result in the destruction or adverse modification of proposed critical habitat. For actions that are not likely to jeopardize the continued existence of a proposed species or adversely modify critical habitat, a conference can be requested by the action agency though it is not required. If requested by the Federal action agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in 50 CFR §402.14. An opinion issued at the conclusion of the conference may be adopted as the biological opinion when the species is listed or critical habitat is designated.

Section 7(b)(3) of the ESA requires that, at the conclusion of consultation and conference, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify their designated or proposed critical habitat. Similarly, when conferring on proposed critical habitat, we also reach a conclusion as to whether the action will satisfy section 7(a)(2) for those entities as proposed. If NMFS determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify designated or proposed critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If incidental take from the action (or reasonable and prudent alternative) is reasonably certain to occur without violating section 7(a)(2), section 7(b)(4), as implemented by 50 CFR §402.14(g)(7) and §402.14(i), requires NMFS to provide an incidental take statement (ITS) that specifies the amount or extent of incidental taking. Take in the ESA is to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). The ITS includes reasonable and prudent measures, which are actions necessary or appropriate to minimize impacts of incidental taking, and terms and conditions to implement the reasonable and prudent measures.

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

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act (89 Fed. Reg. 24268; 84 Fed. Reg. 45015). We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

Consultation in accordance with section 7(a)(2) of the statute (16 U.S.C §1536(a)(2)), associated implementing regulations (50 CFR Part 402), and agency policy and guidance (USFWS and NMFS 1998) was conducted by the NMFS Office of Protected Resources (OPR) ESA Interagency Cooperation Division (hereafter referred to as 'we' or 'us'). We prepared this biological and conference opinion (opinion) and ITS in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR Part 402.

This document represents NMFS's opinion on the effects of these actions on the following ESA-listed species: North Atlantic right whale, blue whale, fin whale, sei whale, Rice's whale, sperm whale, green turtle – North Atlantic Distinct Population Segment (DPS), hawksbill turtle, Kemp's ridley turtle, leatherback turtle, loggerhead turtle – Northwest Atlantic DPS, Atlantic salmon – Gulf of Maine DPS, Atlantic sturgeon – Gulf of Maine DPS, Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Gulf sturgeon, giant manta ray, oceanic whitetip shark, scalloped hammerhead shark – Central and Southwest Atlantic DPS, smalltooth sawfish, Nassau grouper, shortnose sturgeon, elkhorn coral, staghorn coral, pillar coral, rough cactus coral, lobed star coral, mountainous star coral, boulder star coral, and queen conch.

This document also represents NMFS's opinion on the effects of these actions on the following designated or proposed critical habitat: North Atlantic right whale, Rice's whale (proposed), loggerhead turtle – Northwest Atlantic DPS, green turtle – North Atlantic DPS (proposed), Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Gulf sturgeon, Nassau

grouper, elkhorn coral, staghorn coral, pillar coral, rough cactus coral, lobed star coral, mountainous star coral, and boulder star coral.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). A complete record of this consultation is on file electronically with the NMFS OPR in Silver Spring, Maryland and available online in the NOAA Library Institutional Repository <https://repository.library.noaa.gov/welcome>.

1.1 Background

Between 2008 and 2013, NMFS issued multiple biological opinions on military training and testing activities proposed in the Atlantic Ocean and Gulf of America (formerly Gulf of Mexico¹). Initially, these consultations considered training or testing activities in a relatively small geographic location, such as a specific range complex (e.g., research, development, testing, and evaluation activities at U.S. Naval Surface Warfare Center, Panama City, Florida; training activities in the VACAPES, Cherry Point, and JAX Range Complexes), or considered a specific type of exercise over a larger geographic area (e.g., Atlantic Fleet Active Sonar Training along the Atlantic Coast and in the Gulf of America). Where incidental take of marine mammals was anticipated, these consultations also considered the Permits Division's promulgation of regulations and issuance of LOAs pursuant to the MMPA for the Navy to "take" marine mammals incidental to their activities. Each of these opinions concluded that the Navy's and Permits Division's proposed actions would not jeopardize the continued existence of threatened or endangered species or destroy or adversely modify designated critical habitat. Collectively, NMFS and the Navy referred to the activities that were the subject of these consultations as Phase I.²

On November 14, 2013, NMFS issued a biological opinion on proposed Phase II Atlantic Fleet training and testing activities starting in November 2013, and the associated MMPA authorization of incidental take of marine mammals by the Permits Division from November 2013 to November 2018. For the consultation on Phase II activities, the Navy grouped many of the same training and testing activities considered in previous stand-alone consultations into a single proposed action. The opinion concluded that the Navy's and Permits Division's proposed

¹ Executive Order 14172, "Restoring Names That Honor American Greatness" (Jan. 20, 2025), directs that the Gulf of Mexico be renamed the Gulf of America. Accordingly, this opinion hereafter refers to this body of water as the Gulf of America. Likewise, the Navy has renamed the "Gulf of Mexico Range Complex" to the "Gulf Range Complex." We still use "Gulf of Mexico" in some instances where it is part of a proper name (e.g., Northern Gulf of Mexico sperm whale stock) that has not yet been officially changed.

² Note: Since this was the first set of MMPA incidental take regulations, ESA biological opinions, and National Environmental Policy Act Environmental Impact Statements for Navy At-Sea training and testing activities, these activities were referred to as Phase I activities. Subsequent phases were referred to as Phase II, Phase III, and Phase IV, which is the action evaluated under this biological opinion.

actions would not jeopardize the continued existence of threatened or endangered species or destroy or adversely modify designated critical habitat.

On October 22, 2018, NMFS issued a biological and conference opinion (NMFS 2018a) concluding that the Navy's proposed AFTT Phase III activities, and the associated MMPA authorization of incidental take of marine mammals by the Permits Division from November 2018 to November 2023, were not likely to jeopardize the continued existence of threatened or endangered species, and were not likely to result in the destruction or adverse modification of critical habitat.

The 2019 National Defense Authorization Act amended the MMPA for military readiness activities to allow incidental take regulations to be issued for up to seven years instead of the previous five years. After completion of the Phase III AFTT consultation, the Navy submitted an MMPA application requesting that NMFS extend the 2018 AFTT regulations and associated LOAs such that they would cover incidental take for seven years of training and testing activities instead of five, extending the expiration date from November 13, 2023 to November 13, 2025. The Navy submitted a revised application correcting the estimated takes due to ship shock trials to NMFS on January 18, 2019. On May 13, 2019, NMFS published a proposed rule under the MMPA to extend the 2018 AFTT regulations for an additional two years (84 Federal Register [FR] 21126).

The 2018 AFTT Phase III opinion included an ITS exempting incidental take of ESA-listed marine mammals, sea turtles, and fish. On October 25, 2019, we issued an amended ITS that covered the seven-year period to ensure the ITS was consistent with the Permit Division's two-year extension of the 2018 AFTT MMPA regulations. We also issued a Memo for the Record with our conclusion that reinitiation of this consultation under section 7 of the ESA was not warranted for the two-year extension because none of the reinitiation triggers in the 2018 opinion had been met (NMFS 2019e).

The 2018 opinion analyzed the effects of the proposed actions on ESA-listed species, as well as the effect on Rice's whale (reclassified from the Gulf of Mexico Bryde's whale), which was proposed for listing at the time of the Phase III consultation. On April 15, 2019, NMFS published a final rule listing the Rice's whale as endangered. On September 26, 2019, the Permits Division requested that we adopt the conference opinion for the Rice's whale as part of the Phase III biological opinion. Since there had been no significant changes in the action as planned or in the information used during the conference, on October 24, 2019, we notified the Permits Division that we were adopting the Rice's whale conference opinion as the biological opinion. With adoption of the conference opinion as a biological opinion, the ITS provided with the conference opinion (as amended to account for the additional two years) took effect for the Rice's whale.

1.2 Consultation History

Our communication with the Action Proponents and Permits Division regarding this consultation is summarized as follows:

- On March 11, 2024, the Navy sent a draft of the AFTT Explosive and Acoustic Analysis Report, which included changes from Phase III to the Navy's approach to quantifying acoustic effects from sonar and explosives in Phase IV, and estimates of the acoustic impacts to marine mammals and sea turtles.
- On March 19, 2024, we met with the Navy and the Permits Division in San Diego, California to discuss the draft Explosive and Acoustic Analysis Report and provide our initial comments and questions.
- From March 19 through May 10, 2024, we worked with the Permits Division to review and comment on draft versions of the AFTT Explosive and Acoustic Analysis Report.
- On June 14, 2024, the Permits Division notified us that they had received an MMPA Incidental Take Authorization request from the Action Proponents for their AFTT Phase IV activities starting on November 13, 2025.
- On July 11, 2024, the Action Proponents notified us that their draft AFTT Phase IV Biological Assessment (BA) was available for NMFS review. We reviewed the BA and responded with comments and follow up questions on August 2, 2024.
- On August 23, 2024, we received a letter from the Action Proponents requesting formal ESA section 7 consultation for AFTT activities in the Atlantic and Gulf of America beginning in November 2025. The consultation initiation package also included their final AFTT Phase IV BA. The Action Proponents also provided us with responses to our comments and questions from August 2, 2024, and indicated that they were still developing addenda to the BA.
- On September 11, 2024, we notified the Action Proponents that we had accepted their BA as complete. We noted that since the Action Proponents' proposed action is interrelated with the Permits Division's proposed issuance of MMPA regulations, we could not initiate formal ESA section 7 consultation on the AFTT Phase IV proposed action until we received and accepted as complete the Permits Division's initiation package (including the proposed rule).
- On September 25, 2024, we held a BA comment resolution meeting with the Action Proponents and the Permits Division to discuss the responses to our comments and questions.
- On October 9, 2024, we contacted the Office of Protected Resources Marine Mammal and Turtle Conservation Division to request data from the Sea Turtle Stranding and Salvage Network database in support of our sea turtle vessel strike analysis. The requested dataset was provided to us on October 27, 2024.
- On October 22, 2024, we met with the Permits Division to discuss our approach for the AFTT marine mammal vessel strike analysis.

- On October 25, 2024, the Action Proponents sent us an addendum to the AFTT Phase IV BA (Navy 2024a), which included much of the additional information we had requested as part of our review of the BA and follow up correspondence.
- From November 4 through November 6, 2024, we sent the Action Proponents additional questions regarding historical vessel activity and past vessel strikes within the action area. The Action Proponents responded through emails from November 5 through November 15, 2024.
- On November 14, 2024, we met with the Action Proponents and the Permits Division to discuss additional mitigation measures aimed at avoiding or minimizing adverse effects of the proposed action on ESA-listed species.
- On December 10, 2024, we sent the Action Proponents a document titled: *NMFS's Recommended Additional Mitigation Measures for Minimizing Impacts to ESA and MMPA Species from Phase IV Atlantic Fleet Training and Testing Activities*. The primary focus of these recommendations was on minimizing impacts to critically endangered North Atlantic right whales and Rice's whales.
- On December 19, 2024, we sent the Action Proponents a list of additional questions regarding the proposed action. The Action Proponents responded that they received our questions. They also informed us that they were no longer planning to conduct ship shock trials in the Virginia Capes (VACAPES) Range Complex, and, therefore, were removing the VACAPES small ship shock trial box from the proposed action. The Action Proponents indicated that removing the VACAPES Range Complex box will reduce impacts to ESA-listed marine mammals and sea turtles, and that they would provide us with updated acoustic impacts estimates in an addendum to their BA.
- On January 24, 2025, the Action Proponents responded to our recommended additional mitigation measures. On February 3, 2024, the Action Proponents provided us with an updated version of their responses, along with answers to our questions from December 19, 2024.
- On February 12, 2025, we met with the Action Proponents to discuss the recommended additional mitigation measures.
- On March 19, 2025, the NMFS OPR Marine Mammal and Sea Turtle Conservation Division gave a presentation of the North Atlantic Right Whale Persistence Models to the Action Proponents. The presentation was followed by a discussion of the potential use of this model for AFTT mitigation measures to minimize impacts to North Atlantic right whales. NMFS and the Action Proponents agreed to an adaptive management measure to follow up on the use of these models for mitigation purposes within the first year of AFTT Phase IV implementation.
- On March 24, 2025, the Action Proponents provided us with an addendum to the AFTT BA. The addendum included revised acoustic and explosive estimated impacts for marine mammals and sea turtles based on 1) removal of the VACAPES ship shock trial

box and 2) a correction to the sea turtle weighting function used for acoustic threshold criteria used to estimate impacts to sea turtles from sonar, air guns, and explosives.

- On March 26, 2025, we provided the Action Proponents with a draft AFTT biological opinion (which incorporated our conference opinion on Rice's whale proposed critical habitat) for their review.
- On March 27, 2025, we sent the Action Proponents a request for additional information and follow up questions related to mitigation measures.
- From April 10 through April 22, 2025, the Action Proponents provided written comments and suggested edits on the draft AFTT biological and conference opinion.
- On May 9, 2025, NMFS published a proposed rule (90 FR 19858) for the Incidental Take Regulations and three associated LOAs pursuant to the MMPA for the taking of marine mammals incidental to military readiness activities in the Atlantic Fleet Training and Testing action area.
- On May 13, 2025, the Navy sent us a document with their proposed mitigation measures for queen conch to minimize impacts to the species from activities involving in-water explosives off Demolition Key, Florida. On May 21, 2025 we received a section 7 consultation initiation package for AFTT Phase IV from the Permits Division, including the proposed rule for issuance of regulations in accordance with the MMPA. After review of the package we determined that the Permits Division initiation package was sufficient to initiate formal consultation.
- On May 29, 2025 we notified the Action Proponents and the Permits Division that we were initiating formal ESA section 7 consultation.
- On May 30, 2025, the Action Proponents sent us a document summarizing the status of the NMFS recommended additional mitigation measures. Recommended mitigation measures accepted as part of the proposed action include: 1) inclusion of WhaleMap web address and additional language regarding vessel strike risk in the Protective Measures Assessment Protocol (PMAP) reports generated for activities in the Dynamic North Atlantic Mitigation Area; 2) restrictions on propulsion testing events in the North Atlantic Right Whale Feeding Biologically Important Area (BIA) south of Martha's Vineyard and Nantucket Islands, Southeast North Atlantic Right Whale Mitigation Area (from November 15 through April 15), and the Rice's Whale Mitigation Area; 3) issuance of an annual Rice's whale awareness message to AFTT vessels that routinely train or test in the Gulf of America; 4) addition of manta rays and hammerhead sharks to the protected resources list for mitigation during explosive mine neutralization activities with Navy divers; and 5) avoidance of line-charge testing events in nearshore areas off beaches with known sea turtle nesting from March 1 to September 30 within the Panama City Gulf Sturgeon and Sea Turtle Mitigation Area.
- On June 4, 2025, we emailed the Action Proponents additional questions regarding mitigation measures, and included a new recommendation to prohibit detonation of explosive sonobuoys within 3 NM of the Southeast NARW Mitigation Area (from

November 15 through April 15) and the Rice's Whale Mitigation Area (year-round). The Action Proponents responded on June 5, 2025, that these measures had been added to the proposed action.

- On June 27, 2025, we emailed the Action Proponents with the following proposed Term and Condition for the AFTT Phase IV Incidental Take Statement: The Action Proponents shall work collaboratively with the NMFS ESA Interagency Cooperation Division and the NMFS Permits and Conservation Division through the adaptive management process to: 1) analyze and discuss the application of new information from the Rice's whale near real-time detection platform, as it becomes available; 2) evaluate the practicability and conservation benefits of newly proposed mitigation measures and/or changes to existing measures based on information from the Rice's whale near real-time detection platform; and 3) implement any new mitigation measures or changes to existing measures that meet the Action Proponents' Practicability Criteria and Sufficiently Beneficial requirements.

1.3 Analytical Approach

This opinion includes a jeopardy analysis for the ESA-listed species and an adverse modification or destruction of critical habitat analysis for the designated and proposed critical habitat within the action area. "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of an ESA-listed species as a whole (50 CFR §402.02). Prior to 2016, the designation(s) of critical habitat used the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR §424.12) replaced these terms with the term physical and biological feature (PBF). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether an action agency is able to insure its proposed action is not likely to jeopardize listed species or destroy or adversely modify designated or proposed critical habitat:

- Identify all aspects of the proposed action (as defined in 50 CFR §402.02), including activities that rely on the action for their occurrence. This section also includes any avoidance and minimization measures that have been incorporated into the proposed action to reduce the effects to ESA-listed species.

- Identify the physical, chemical, and biological modifications to land, water, and air (stressors) that result from those actions and subsequent activities.
- Establish the spatial extent of those stressors, which is the action area (50 CFR §402.02).
- Identify the listed species (as defined at 16 U.S.C. §1532(16)) and designated and proposed critical habitat (as defined at 16 U.S.C. §1532(5)) in the action area.
- Identify the species and critical habitats that are not likely to be adversely affected by the action.
- Evaluate the range-wide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline (as defined in 50 CFR §402.02) as it pertains to the species and critical habitat.
- Evaluate the effects of the proposed action on listed species and their designated or proposed critical habitat using an exposure-response approach. When complete, this section anticipates the amount or extent, as well as the forms (harass, harm, etc.), of take of listed species (or a surrogate) that is reasonably certain to occur as a result of the action, as well as the extent of effects to critical habitat.³
- Evaluate cumulative effects (as defined at 50 CFR §402.02).
- Produce an integration and synthesis, where we add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat.
- Concisely compile the conclusions of our jeopardy and destruction or adverse modification analysis conclusions relying on the justification in the integration and synthesis.
- If the opinion determines the action agencies failed to insure their actions are not likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat, we suggest a reasonable and prudent alternative to the proposed action and assess the effects of that alternative action.
- For actions that do not violate section 7(a)(2) of the ESA or an alternative action is identified that does not violate section 7(a)(2) of the ESA, and when take of marine mammals is permitted under section 101(a)(5) of the MMPA, after we conclude our opinion, we provide an ITS that specifies the impact of the take on listed species

³ Because take is categorized differently under ESA and MMPA, the initiation documents provided by Action Proponents, NMFS's Permits Division, and the analysis in this opinion may discuss take differently and identify different numbers of takes as the reasonably certain outcomes of this action (see interim guidance at <https://www.fisheries.noaa.gov/s3/2023-05/02-110-19-renewal-kdr.pdf>).

(amount or extent), reasonable and prudent measures, and terms and conditions to implement those measures.

In each of these steps above, we rely on the best scientific and commercial data available. To conduct the analyses necessary for this opinion, and to comply with our obligation to use the best scientific and commercial data available, we considered all lines of evidence available through published and unpublished sources. We conducted electronic literature searches throughout this consultation, including within the NMFS Office of Protected Resources' electronic library.

This opinion is based on information provided by the Action Proponents during pre-consultation technical assistance and other supplemental information provided throughout the consultation process. We examined the AFTT Phase IV Biological Assessment (BA) (Navy 2024c), AFTT Phase IV Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement Version 2 (Navy 2024c), AFTT Phase III annual monitoring reports, literature cited in these documents, and other supplemental information provided throughout the consultation process. We also evaluated the Navy's annual and comprehensive monitoring reports required under the existing MMPA rule and LOAs and the previous biological opinion for current training and testing activities occurring in the same geographic area. In addition, we engaged regularly with the Navy to discuss new science and technical issues as part of the ongoing adaptive management⁴ program for Navy military readiness activities and incorporated new information obtained as a result of these engagements in this consultation.

This opinion also considers information provided by NMFS's Permits Division, including its request for initiation of section 7 consultation under the ESA, which included the proposed Federal regulations under the MMPA to authorize the incidental take of marine mammals, including ESA-listed marine mammals, specific to the proposed activities (90 FR 19858) and related draft LOAs.

We incorporated information from NMFS's draft or final recovery plans, species status reports, 5-year status review updates, and critical habitat reports for the endangered or threatened species considered in this document, and examined scientific literature on ESA-listed species and habitats. We identified information relevant to the potential stressors and responses of ESA-listed species and critical habitat (designated and proposed) under NMFS's jurisdiction that may be affected by the AFTT Phase IV activities.

⁴ The MMPA regulations governing the take of marine mammals incidental to military readiness activities in the AFTT action area contain an adaptive management component. Adaptive management allows for consideration of new information from different sources to determine, on an annual or biennial basis, if the mitigation or monitoring measures should be modified. More details regarding the adaptive management component can be found in the AFTT MMPA rule at <https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities>

Collectively, we consider the information described above to comprise the best scientific and commercial information available for this consultation and in preparation of this opinion.

2 DESCRIPTION OF THE PROPOSED ACTION

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the U.S. or on the high seas. Examples include, but are not limited to: 1) actions intended to conserve listed species or their habitat; 2) the promulgation of regulations; 3) the granting of licenses, contracts, leases, easements, rights-of-way, permits, or grants in aid; or 4) actions directly or indirectly causing modifications to the land, water, or air (50 CFR §402.02).

Two Federal actions were evaluated during this consultation. The first action is the Action Proponents’ military training and testing activities conducted in the AFTT action area into the reasonably foreseeable future. The second action is the Permits Division’s implementation of the MMPA through: 1) promulgation of regulations pursuant to the MMPA as amended (16 U.S.C. 1361 et seq.) governing the Action Proponents’ “take” of marine mammals incidental to military readiness activities within the AFTT action area through November 2032; and 2) issuance of LOAs pursuant to the regulations that authorize the Action Proponents to “take” marine mammals under the MMPA incidental to military readiness activities within the AFTT action area through November 2032.

The Action Proponents propose to conduct military readiness training and testing activities, collectively referred to as “military readiness activities,” which include the use of active sonar and explosives, in the western Atlantic Ocean along the eastern coast of North America, the Gulf of America, in portions of the Caribbean Sea, at Navy pier side locations, within port transit channels, near civilian ports, and in bays, harbors, and inshore waterways (e.g., lower Chesapeake Bay). The Action Proponents have historically used the areas along the eastern coast of the U.S. and in the Gulf of America for training and testing. The Action Proponents use a combination of undersea ranges, operating areas (OPAREAs), land training ranges, divert airfields, and nearshore amphibious landing sites to achieve their training and testing objectives (Navy 2024c). OPAREAs are specific ocean areas within a range complex defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace (Navy 2024c). Within an OPAREA there is a restricted area that is defined to prohibit or limit public access to the area.

NMFS recognizes that while the Action Proponents’ training and testing requirements change over time in response to global or geopolitical events and other factors, the general types and tempo of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assume that the training and testing activities proposed by the Action Proponents during the 7-year period of the Permits Division’s proposed incidental take authorization pursuant to the

MMPA will continue into the reasonably foreseeable future at levels similar to those assessed in this opinion.

Below, we present information on: the primary mission areas, specific types of military readiness activities, and activity levels proposed in the different locations throughout the action area (Sections 2.1 and 2.2); the standard operating procedures and mitigation measures that will be implemented by the Action Proponents as part of their training and testing activities (Section 2.3); and the stressors resulting from the proposed activities (Section 2.4). In Section 2.5 we discuss the Permits Division’s proposed action under the MMPA.

More details regarding the proposed action can be found in the Action Proponents’ AFTT BA (Navy 2024c). We incorporate, by reference, specific sections of the BA into this opinion, following our review of their sufficiency, where appropriate.

2.1 Primary Mission Areas

The Action Proponents categorize their activities into functional warfare areas called primary mission areas. These activities generally fall into the following seven primary mission areas, with testing activities being the same or similar to training activities (Table 1).

Table 1. Primary Mission Areas and Associated AFTT Activities (Navy 2024c)

Primary Mission Area	Description	Typical Activities
Air Warfare	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.	Air Combat Maneuver; Air Defense exercises; Gunnery and Missile Exercises (air-to-air and surface-to-air)
Amphibious warfare	Individual and crew training includes shore assaults, boat raids, airfield or port seizures, reconnaissance, and disaster relief. Large-scale amphibious exercises involve ship-to-shore maneuvers, naval fire support (such as shore bombardment), air strikes, and attacks on targets that are in close proximity to friendly forces. Testing activities are often integrated into training activities.	Amphibious Assault; Amphibious Operations in Contested Environment; Amphibious Raid; Ready Group Marine Expeditionary Unit Exercise; Squadron Marine Expeditionary Unit Integration Training; Vehicle Maneuvers; Naval Surface Fire Support Exercise (At-sea and Land-based); Non-Combat Evacuation Operation

Primary Mission Area	Description	Typical Activities
Anti-submarine warfare	Training includes detecting and classifying submarines, evaluating ocean sounds, tracking a submarine, attacking a target using either exercise torpedoes (i.e., torpedoes that do not contain a warhead) or simulated weapons. Testing uses ships, submarines, and aircraft to demonstrate capabilities of torpedoes, missiles, countermeasure systems, and underwater surveillance and communications systems.	Torpedo Exercises (Helicopter, Maritime Patrol Aircraft, Ship, Submarine); Tracking Exercises (Helicopter, Maritime Patrol Aircraft, Ship, Submarine)
Electronic warfare	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.	Counter Targeting Chaff Exercises – Aircraft/Ship; Counter Targeting Flare Exercise; Electronic Warfare Operations; High-Speed Anti-Radiation Missile Exercise
Expeditionary warfare	Includes defense of harbors, operation of remotely operated vehicles, defense against swimmers, boarding/seizure operations, underwater construction, dive and salvage operations, and insertion/extraction via air, surface, and subsurface platforms.	Dive and Salvage Operations; Personnel Insertion/Extraction – Air, Surface and Subsurface, and Swimmer/Diver training; Port Damage Repair and Underwater Construction Training
Mine warfare	Training includes mine detection and classification, mine countermeasure and neutralization, and offensive mine laying. Testing focuses on the development of mine warfare systems to improve sonar, laser, and magnetic detectors intended to hunt, locate, and record the positions of mines.	Airborne Mine Countermeasures – Mine Detection and Towed Mine Neutralization; Airborne Mine Laying; Civilian Port Defense Exercises; Coordinated Unit-Level Helicopter Airborne Mine Countermeasures Exercise; Installation and Maintenance of Mine Training Areas; Mine Countermeasures/ Neutralization – Remotely Operated Vehicles; Mine Countermeasures – Ship Sonar; Mine Neutralization – Explosive Ordnance Disposal; Submarine Mobile Mine and Mine Laying Exercise; Surface Ship Object Detection; Underwater Mine Countermeasures Operations

Primary Mission Area	Description	Typical Activities
Surface warfare	Training includes gunnery and missile exercises, submarine missile or torpedo launch events, and other munitions against surface targets. Testing of weapons is conducted to develop new technologies and to assess weapon performance and operability.	Bombing Exercise Air-to-Surface; Gunnery Exercises - Air-to-Surface and Surface-to-Surface; Integrated Live Fire Exercise; Laser Targeting – Aircraft and Ship; Long-Range Unmanned Surface Vessel Training; Maritime Security Operations; Missile Exercises - Air-to-Surface, Air-to-Surface Rocket, and Surface-to-Surface; Sinking Exercise; Small Boat Attack

Most activities proposed by the Action Proponents are categorized into one of these primary mission areas. Other activities that do not fall within one of these primary mission areas include:

- Ship-to-Shore Fuel Transfer System Training
- Precision Anchoring
- Search and Rescue
- Submarine Navigation
- Submarine Sonar Maintenance and Systems Checks
- Submarine Under Ice Certification
- Surface Ship Sonar Maintenance and Systems Checks
- Unmanned Aerial System Training and Certification – Submarine
- Unmanned Underwater Vehicle Training - Certification and Development
- Waterborne Training (Navy 2024c)

The Navy is organized into warfare communities that encompass various specialized areas, including Surface Warfare, Undersea Warfare, Aviation Warfare, and Expeditionary Warfare. Each warfare community 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. The testing community has three additional categories of activities for vessel evaluation, unmanned systems, and acoustic and oceanographic science and technology. A more detailed description of each of the seven primary mission areas and associated activities or exercises is provided in the AFTT BA (Section 2.2, pp. 2-12 through 2-15), which we incorporate into this opinion by reference (Navy 2024c).

2.2 Proposed Military Readiness Activities

While the Action Proponents have been conducting military readiness activities in the AFTT action area for decades, the tempo and types of training and testing activities have changed over time due to the introduction of new technologies, the evolving nature of international events, advances in warfighting doctrine and procedures, and changes in force structure (organization of ships, weapons, and personnel). Such developments influence the frequency, duration, intensity, and location of required military readiness activities. The types and numbers of activities proposed by the Action Proponents reflect the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements and account for fluctuations in training and testing in order to meet evolving or emergent military readiness requirements.

For the training activities considered during consultation, Naval personnel (Sailors and Marines) and Coast Guard personnel (Coast Guardsmen) first undergo entry-level (or schoolhouse) training, which varies according to their assigned warfare community (aviation, surface warfare, submarine warfare, and expeditionary warfare) and the community's unique requirements. Personnel then train within their warfare community at sea in preparation for deployment (Navy 2024c). For the testing activities considered during consultation, the Navy researches, develops, tests, and evaluates new platforms, systems, and technologies, collectively known as testing. Many tests require realistic conditions at sea and can range from testing new software to complex operations of multiple systems and platforms. Testing activities may occur independent of or in conjunction with training activities (Navy 2024c).

2.2.1 Training Activities

The AFTT BA describes all of the Navy (Section 2.3.1, Table 2.3-2, pp 2-18 through 2-22) and Coast Guard (Section 2.3.1.1, Table 2.3-4, pp. 2-32 through 2-33) training activities as part of the proposed action. We incorporate these tables into our opinion by reference (Navy 2024c). A more detailed description of the sonar, munitions, targets, systems, and other material used during training activities can be found in Appendix A, *Activity Descriptions* of the AFTT EIS/Overseas EIS (Navy 2024d).

The activity levels and general locations (e.g., range complex, port) of each type of training activity proposed are provided in the AFTT BA (Section 2.3.1, Table 2.3-3, pp. 2-22 through 2-30 for Navy activities; Section 2.3.1.1, Table 2.3-5, pp. 2-33 through 2-35 for Coast Guard activities). We incorporate Table 2.3-3 and Table 2.3-5 of the BA into this opinion by reference (Navy 2024c).

Major Training Exercises and Integrated/Coordinated Training Activities

While most AFTT training exercises are conducted by a single military unit, the proposed action also includes major training exercises (MTEs), and integrated and coordinated exercises, which are comprised of multiple "unit-level" exercises conducted by several units operating together under the command and control of a single commander. Integrated or coordinated anti-submarine

warfare exercises are generally on a smaller scale than MTEs, 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 for deployment (Navy 2024c). The description and location of MTEs and integrated/coordinated training activities included in the proposed action are shown in Table 2. There are no MTEs, integrated exercises, or coordinated exercises proposed for the Gulf Range Complex for AFTT Phase IV.

Table 2. Major Training Exercises and Integrated/Coordinated Training Activities Included in the Proposed Action (Navy 2025a)

	<i>Exercise Group</i>	<i>Description</i>	<i>Scale</i>	<i>Duration</i>	<i>Location (Range Complex)</i>	<i>Exercise Examples</i>	<i>Typical Hull-Mounted Sonar per Event</i>
<i>Major Training Exercise</i>	Large Integrated ASW	Larger-scale, longer duration integrated ASW exercises	Greater than 6 surface ASW units (up to 30 with the largest exercises), 2 or more submarines, multiple ASW aircraft	Generally greater than 10 days	Jacksonville Range Complex Navy Cherry Point Range Complex Virginia Capes Range Complex	COMPTUEX	<500 hours
	Medium Integrated ASW	Medium-scale, medium duration integrated ASW exercises	Approximately 3-8 surface ASW units, at least 1 submarine, multiple ASW aircraft	Generally 4–10 days	Jacksonville Range Complex Navy Cherry Point Range Complex Virginia Capes Range Complex	Sustainment/ Task Force Exercise	100-300 hours
<i>Integrated/Coordinated Training</i>	Small Integrated ASW	Small-scale, short duration integrated ASW exercises	Approximately 3-6 surface ASW units, 2 dedicated submarines, 2-6 ASW aircraft	Generally less than 5 days	Jacksonville Range Complex Navy Cherry Point Range Complex Virginia Capes Range Complex	SWATT, NUWTAC	50-100 hours
	Medium Coordinated ASW	Medium-scale, medium duration, coordinated ASW exercises	Approximately 2-4 surface ASW units, possibly a submarine, 2-5 ASW aircraft	Generally 3-10 days	Jacksonville Range Complex Navy Cherry Point Range Complex Virginia Capes Range Complex	ASW Tactical Development Exercise	Less than 100 hours
	Small Coordinated ASW	Small-scale, short duration, coordinated ASW exercises	Approximately 2-4 surface ASW units, possibly a submarine, 1-2 ASW aircraft	Generally 2-4 days	Jacksonville Range Complex Navy Cherry Point Range Complex Virginia Capes Range Complex	ARG/MEU COMPTUEX	Less than 50 hours

Notes: ARG/MEU = Amphibious Ready Group/Marine Expeditionary Unit; ASW = anti-submarine warfare; COMPTUEX = Composite Training Unit Exercise; SWATT = Surface Warfare Advanced Tactical Training Exercise; NUWTAC = Navy Undersea Warfare Training Assessment Course

2.2.2 Testing Activities

Navy testing activities occur in response to emerging science or fleet operational needs. The Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (e.g., missiles, radar, and sonar) and platforms (e.g., surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions. The individual commands within the Navy's research and acquisition community included in the proposed action are Naval Air Systems Command (NAVAIR), Naval Sea Systems Command (NAVSEA), and the Office of Naval Research (ONR). The Coast Guard action does not include any testing activities (only training).

NAVAIR testing activities support its mission to provide full life cycle support of naval aviation aircraft, weapons, and systems to be operated by the Action Proponents (Navy 2024c). NAVAIR activities closely follow fleet primary mission areas, such as the testing of airborne mine warfare and anti-submarine warfare weapons and systems. NAVAIR activities include, but are not limited to, the testing of new aircraft platforms, weapons, and systems that have not yet been integrated into the fleet and Coast Guard (Navy 2024c). In addition to testing new platforms and weapon systems, most aircraft and weapon systems that have been integrated into the fleet also require follow-on testing throughout their lifecycle in conjunction with maintenance and upgrades, such as software revisions, to ensure that they function as designed. Table 2.3-6 of the AFTT BA (Section 2.3.2.1, pp. 2-36 through 2-38) describes the NAVAIR testing activities, and Table 2.3-7 (Section 2.3.2.1, pp. 2-39 through 2-41) provides the number and location of NAVAIR testing activities that will occur under the proposed action. We incorporate these tables here by reference (Navy 2024c).

NAVSEA activities are aligned with its mission of new ship construction, life cycle management, and weapon systems development (Navy 2024c). NAVSEA activities include pier-side 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); developmental and operational test and evaluation programs for new technologies and systems; and testing on all ships and systems that have undergone overhaul or maintenance (Navy 2024c). At-sea test firing of shipboard weapon systems, including guns, torpedoes, and missiles, is also proposed as part of NAVSEA testing activities. Table 2.3-8 of the AFTT BA (Section 2.3.2.2, pp. 2-41 through 2-43) describes the NAVSEA testing activities, and Table 2.3-9 (Section 2.3.2.2, pp. 2-44 through 2-49) provides the number and location of NAVSEA testing activities that will occur under the proposed action. We incorporate these tables here by reference (Navy 2024c).

ONR manages the Navy's basic, applied, and advanced research. ONR 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 (Navy 2024c). Testing activities conducted by ONR and the Naval Research Laboratory include acoustic and oceanographic research, unmanned underwater vehicle research, and next generation mine countermeasures research. Tables 2.3-10 and 2.3-11 of the AFTT BA (Section 2.3.2.3, p. 2-50) describe the ONR testing activities and the number and location of ONR testing activities, respectively, that will occur under the proposed action. We incorporate these tables here by reference (Navy 2024c).

2.2.3 Foreign Military Activities

Occasionally, but infrequently, foreign allies' military forces may participate in U.S.-led training exercises or test systems while operating with U.S. assets. Foreign military surface vessels may participate opportunistically during U.S.-led training and testing activities while in the action area, or they may participate by invitation. Additionally, on occasion the U.S. provides access to foreign vessels to use an instrumented testing range. In these cases, the U.S. may provide support ranging from deconfliction of the range to support with instrumentation.

Foreign military vessel activities in the AFTT action area that are planned by and under the substantial control and responsibility of the U.S. Navy are included in the proposed action (Busch 2025). However, when foreign military vessels and aircraft operate independently within the action area as sovereign vessels and aircraft outside the planning, control, and responsibility of the Action Proponents, those activities are not considered part of the proposed action (Busch 2025), nor would the resulting stressors be considered a consequence of the proposed action. There are many reasons why foreign military vessels may traverse U.S. waters or come into U.S. port, not all of which are at the request of any of the Action Proponents. Foreign military vessels and aircraft operate pursuant to their own national authorities and have independent rights under customary international law, embodied in the principle of sovereign immunity, to engage in various activities on the world's oceans and seas.

We evaluate the potential effects of foreign military vessel activity and resulting stressors on ESA-listed species critical habitat only when such vessels are actively participating in U.S. Navy-led training or testing exercises within the AFTT action area, and under the substantial control and responsibility of the U.S. Navy. For purposes of this opinion, the potential effects of foreign military vessel activity within the AFTT action area when such vessels are not actively participating in U.S. Navy-led training or testing exercises will either be considered part of the environmental baseline (i.e., for past or present activity) or part of our cumulative effects analysis (i.e., for future non-U.S. Federal activity). Therefore, the effects of foreign military vessels operating in any capacity on ESA-listed species or critical habitat in the action area are fully considered and evaluated in this opinion.

Other than scenarios when a foreign military vessel actively participates in an AFTT U.S. Navy exercise, foreign military vessels operating within the action area may adhere to their own

standard operating procedures and environmental mitigation measures. When a foreign military vessel participates in a U.S. Navy exercise within the U.S. territorial sea (i.e., 0 to 12 nm from shore), the U.S. Navy will request that the foreign vessel follow the U.S. Navy's mitigation measures for that particular event. When a foreign military vessel participates in a U.S. Navy exercise beyond the U.S. territorial sea but within the U.S. Exclusive Economic Zone, the U.S. Navy will encourage the foreign vessel to follow the U.S. Navy's mitigation measures for that particular event (Navy 2022b; Navy 2022c). In either scenario (i.e., both within and beyond the territorial sea), U.S. Navy range operators will provide the foreign vessel with the appropriate mitigation so that they can follow the mitigation measures (Navy 2021). Since the Action Proponents have indicated that compliance with such measures cannot be legally mandated on a foreign entity, compliance by foreign vessels isn't assumed to reach our effects determinations and conclusions. However, a high level of voluntary compliance is anticipated given the context (i.e., a foreign ally that is invited to participate with the U.S. Navy in a formal military readiness exercise) and past experience.

Foreign military vessel activities within the AFTT action area typically include one or two port visits, a weapons system test, and/or participation in a MTE (Navy 2025c). There are no recurring, large-scale, multi-national exercises as part of the AFTT proposed action, and foreign military vessels account for a very small proportion of AFTT activity levels, overall. For example, over the past 11 years, less than 0.6% of ordnance events involved foreign military vessels (Navy 2025c).

2.3 Standard Operating Procedures and Mitigation Measures

The primary purpose of the Action Proponents' standard operating procedures is to provide for safety and mission success. In some cases there are environmental benefits resulting from their implementation as well. Mitigation measures are designed specifically to avoid or reduce environmental impacts from the proposed activities. The standard operating procedures and mitigation measures the Action Proponents will incorporate in their training and testing activities in the action area are described below (Navy 2024c).

2.3.1 Standard Operating Procedures

Standard operating procedures have been developed by the Action Proponents over many years of experience conducting military readiness activities. Standard operating procedures are broadcast via numerous naval instructions and manuals to ensure compliance (Navy 2024c). NMFS considers these procedures as reasonably certain to be implemented and thus components of the proposed action. For purposes of this consultation, the standard operating procedures that could result in conservation benefits to ESA-listed species or their habitats are described below.

Many ESA-listed species occur primarily or entirely within inland waters (e.g., bays, estuaries, rivers) or the coastal zone, which extends three nautical miles (NM) from the shore throughout most of the action area and 9 NM from the shore of Texas, Florida's Gulf Coast, and Puerto

Rico. As a standard operating procedure, Action Proponents typically do not conduct the training and testing activities listed in Tables 3 and 4 within coastal zones or inland waters due to mission specific requirements. As such, nearshore and/or inland water associated species (e.g., green sea turtles, smalltooth sawfish, and shortnose sturgeon) are less likely to be exposed to the stressors resulting from these activities, which typically occur in the offshore portions of the action area.

Several standard operating procedures designed for safety may also increase the effectiveness of Lookouts in sighting ESA-listed species and implementing the activity-based mitigation measures described in Section 2.3.2 below. These include the following:

- Underway surface ships operated by or for the Action Proponents have personnel assigned to stand watch at all times (day and night) for safety of navigation, collision avoidance, range clearance, and man-overboard precautions.
- Navy personnel are trained in accordance with the U.S. Navy Lookout Training Handbook (Navy 2022a), which was updated in 2022 to include a more robust chapter on environmental compliance, mitigation, and marine species observation tools and techniques. Coast Guard Lookouts receive wildlife training that is similar to the Navy training.
- After sunset and prior to sunrise, Lookouts employ night visual search techniques, which could include the use of night vision devices.
- Most in-water explosive activities are conducted only during daylight hours.
- Weapon firing activities that involve small boats deploying or retrieving targets are typically conducted in Beaufort Sea-state number 4 conditions or better.
- Aircrew are not authorized to deploy ordnance through extensive cloud cover where visual clearance for non-participants is not possible. Exceptions: 1) when operating in the open ocean, clearance 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.
- In accordance with applicable navigation rules, Action Proponent vessels must proceed at a safe speed, at all times, 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.
- Manned support vessels may escort unmanned surface or underwater vehicles. In addition, unmanned vehicles may have embedded sensors (e.g., forward looking sonar) designed for avoidance of large objects.
- As a standard collision avoidance procedure for in-water devices towed by surface vessels (or by unmanned vehicles under positive control by manned support vessels), the Action Proponents search the intended path of the towed in-water device for floating debris, concentrations of floating vegetation, floating objects, or animals with potential to obstruct, tangle, or damage the device (Navy 2024c).

Other standard operating procedures designed for safety or mission success that may also provide conservation benefits include the following:

- Only properly trained and authorized personnel operate high-energy lasers within designated areas.
- During activities that involve recoverable targets, the Action Proponents recover the target and any associated decelerators or parachutes to the maximum extent practical consistent with personnel and equipment safety.
- In general, aircrew do not intentionally generate sonic booms below 30,000 feet (ft) of altitude unless over water and more than 30 miles from inhabited land areas or islands (exceptions may apply).
- Action Proponent vessels avoid known navigation hazards that appear on nautical charts, such as submerged wrecks and obstructions, and with limited exceptions (e.g., amphibious vessels operating in designated locations, bottom-crawling vehicles), manned vessels and unmanned vehicles avoid contact with the seafloor (Navy 2024c).

During pile driving activities, due to the system design, the Action Proponents perform soft starts during impact installation of each pile to ensure proper operation of the diesel impact hammer. During a soft start, the Action Proponents perform an initial set of strikes from the impact hammer at reduced energy before it can be operated at full power and speed.

Table 3. AFTT Training Activities Typically not Conducted within the Coastal Zone (Navy 2024c)

<i>Air Warfare</i>	<i>Mine Warfare</i>
• Air Combat Maneuvers¹ • Air Defense Exercise • Gunnery Exercises ◦ all Air-to-Air ◦ all Surface-to-Air • Missile Exercises ◦ Air-to-Air ◦ Surface-to-Air	• Mine Detection ◦ Mine Countermeasure Exercise – Ship Sonar • Mine Laying ◦ Aircraft ◦ Submarine launched
<i>Amphibious Warfare</i>	<i>Surface Warfare</i>
• Naval Surface Fire Support Exercise-At Sea • Naval Surface Fire Support Exercise-Land Based Target	• Gunnery Exercises ◦ All Air-to-Surface ◦ All Surface-to-Surface • Missile Exercise ◦ Air-to-Surface (Missile and Rocket) ◦ Surface-to-Surface • Laser Targeting ◦ Aircraft ◦ Ship • Integrated Live Fire • Bombing Exercise • Sinking Exercise²
<i>Anti-Submarine Warfare</i>	<i>Major Training Exercise</i>
• Torpedo Exercise ◦ Helicopter ◦ Maritime Patrol Aircraft ◦ Submarine ◦ Ship • Tracking Exercise ◦ Helicopter ◦ Maritime Patrol Aircraft ◦ Submarine ◦ Ship	• Composite Training Unit Exercise • Sustainment/ Task Force Exercise
<i>Integrated/Coordinated Anti-Submarine Warfare</i>	<i>Other Training Activities</i>
• Anti-Submarine Warfare Tactical Development Exercise • Group Sail • Navy Undersea Warfare Training Assessment Course • Surface Warfare Advanced Tactical Training	• Submarine Navigation • Submarine Under Ice Certification
	<i>Electronic Warfare</i>
	• Counter Targeting ◦ Chaff-Aircraft ◦ Chaff-Ship ◦ Flare-Aircraft

¹ Air Combat Maneuver typically occurs outside the coastal zone, with an exception in the Key West Range Complex (KWRC).

² This activity only occurs in a designated area, which is located outside of the coastal zone.

Table 4. AFTT Testing Activities Typically not Conducted within the Coastal Zone (Navy 2024c)

<i>Air Warfare</i>	<i>Surface Warfare</i>
• 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	• Air-to-Surface Bombing Test • Air-to-Surface Gunnery Test • Air-to-Surface Missile Test • Air-to-Surface High-Energy Laser Test • Laser Targeting Test • Rocket Test • Gun Testing – Large-Caliber • Gun Testing – Medium-Caliber • Gun Testing – Small-Caliber • Missile and Rocket Testing • Maritime Security Operations
<i>Anti-Submarine Warfare</i>	<i>Other Testing Activities</i>
• Anti-Submarine Warfare Torpedo Test • Anti-Submarine Warfare Tracking Test – Rotary Wing • Kilo Dip • Sonobuoy Lot Acceptance Test • Torpedo (Explosive) Testing¹ • At-Sea Sonar Testing	• Air Platform Shipboard Integration Test • Shipboard Electronic Systems Evaluation • Acoustic Component Testing • Chemical and Biological Simulant Testing (coastal zone of Maine only) • Non-Acoustic Component Testing
<i>Electronic Warfare</i>	
• Chaff Test • Electronic Systems Evaluation • Flare Test	
<i>Mine Warfare</i>	
• Mine Laying Test	
<i>Vessel Evaluation</i>	
• Air Defense Testing • Propulsion Testing • Surface Warfare Testing • Small Ship Shock Trial¹ • Submarine Sea Trials – Propulsion Testing • Submarine Sea Trials – Weapons System Testing • Signature Analysis Operations	
	<i>Unmanned Systems</i>
	• Underwater Search, Deployment, and Recovery
	<i>Acoustic and Oceanographic Science and Technology</i>
	• Acoustic and Oceanographic Research • Electronic Systems Test • Large Displacement Unmanned Underwater Vehicle Testing

¹ This activity only occurs in designated areas, which are located outside of the coastal zone.

2.3.2 Mitigation Measures⁵

The Action Proponents propose to implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors from military readiness activities on ESA-listed species and designated or proposed critical habitat in the action area. NMFS considers these measures as reasonably certain to be implemented and thus

⁵ We consider these mitigation measures “conservation measures”: actions that will be taken by the Action Proponents and serve to minimize project effects on the species under review. As such, we evaluate the effects of these measures as integral parts of the proposed action to be implemented.

components of the proposed action. Mitigation measures fall into two main categories: activity-based mitigation and geographic mitigation.

The Action Proponents will publish, broadcast, disseminate, or distribute mitigation instructions through pre-event briefs, governing instructions, broadcast messages, the PMAP, or other established internal processes (Navy 2024c). The PMAP is a software program accessed by appointed Action Proponent personnel during pre-event planning. The program provides operators with notification of the required mitigation measures applicable to a particular training or testing event, as well as a visual display of the planned event location overlaid with relevant environmental data. Its text and mapping data will be updated to align with best available science and the final mitigation that results from this consultation (Navy 2024c).

Environmental awareness and education training is also provided to personnel through the Afloat Environmental Compliance Training program or equivalent. Upon reporting aboard and annually thereafter, appointed personnel must complete training identified in their career path training plan (Navy 2024c), which may include the following training modules:

- *Introduction to Afloat Environmental Compliance* - provides information on at-sea environmental laws, regulations, and compliance roles.
- *Marine Species Awareness Training* - provides information on marine species sighting cues, visual observation tools and techniques, and sighting notification procedures.
- *PMAP Training* - provides information on how personnel should access and operate the PMAP.
- *Sonar Positional Reporting System and Marine Mammal Incident Reporting* - provides information on sonar reporting requirements and marine mammal incident reporting procedures.

Mitigation requirements are mandatory for the Action Proponents when conducting activities under the proposed action. Foreign militaries may actively participate alongside the Action Proponents in multinational training and testing events in the action area. Foreign military vessel activities are not considered part of the federal action, nor are the resulting stressors considered a consequence of the proposed action, unless the U.S. military plans and exercises substantial control and responsibility over those foreign military vessel activities (Navy 2024c). Foreign military vessels operate pursuant to their own national authorities and have independent rights under customary international law, embodied in the principle of sovereign immunity, to engage in various activities on the world's oceans and seas (Navy 2024c). During U.S.-led training events within the U.S. territorial seas (0 to 12 NM from shore), the Action Proponents will request a foreign military unit's voluntary compliance with the applicable mitigations. When a foreign military unit participates in a training event with the Action Proponents beyond the U.S. territorial seas but within the U.S. Exclusive Economic Zone (EEZ) (12 to 200 NM from shore), the Action Proponents will encourage the unit's voluntary compliance with the mitigation when

practical. While compliance with such measures cannot be legally mandated on a foreign entity, as discussed above (Section 2.2.3), we anticipate a relatively high level of voluntary compliance.

The following sections summarize the mitigation measures that the Action Proponents propose to implement in association with the training and testing activities analyzed in this document. Most of these proposed mitigation measures are carried over from AFTT Phase III. New (or modified) mitigation measures proposed for Phase IV that are relevant to this consultation are discussed below. A complete discussion of the mitigation measures, as well as measures considered but not proposed, and the evaluation process used by the Action Proponents to develop, assess, and select mitigation measures, can be found in the Final Supplemental EIS/OEIS⁶ for this action.

Activity-based Mitigation

Activity-based mitigations have a primary objective of reducing overlap of individual marine mammals and sea turtles in real time with stressors that have the potential to cause injury or mortality (Navy 2024c). Activity-based mitigation generally involves: (1) the use of one or more trained Lookouts to observe for specific biological resources within a mitigation zone⁷; (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate watch station for information dissemination; and (3) requirements for the watch station to implement mitigation (e.g., halt an activity) until certain recommencement conditions have been met.

Lookouts are personnel who perform similar duties as the standard watch personnel but have an additional duty of helping meet the mitigation requirements by visually observing mitigation zones for marine mammals and sea turtles. For some activities, Lookouts may also be required to observe for additional biological resources, such as birds, fish, jellyfish aggregations, or floating vegetation (i.e., *Sargassum*), which can be indicators of potential marine mammal or sea turtle presence.

Depending on the activity, a Lookout may be positioned on a surface ship or small boat, in an aircraft, on a pier, or on the shore. Certain platforms, such as aircraft and small boats, have manning or space restrictions; therefore, the Lookout on these platforms is typically an existing member of the aircraft or boat crew (e.g., pilot) who is responsible for other essential tasks (e.g., navigation). On platforms that do not have manning and space restrictions (such as large ships), the Officer of the Deck, a member of the bridge watch team, or other personnel may be designated as one of the Lookouts.

⁶ Final EIS/OEIS will be posted at <https://www.fisheries.noaa.gov/action/incidental-take-authorization-military-readiness-activities-atlantic-fleet-training-and>

⁷ Mitigation zones are areas at the surface of the water (measured as the radius from a stressor) within which training or testing activities would be halted, powered down, or modified to protect specific biological resources from an injurious impact (e.g., Permanent Threshold Shift [PTS], vessel strike).

The Action Proponents have added a requirement (new for AFTT Phase IV) for additional personnel on the platform conducting an event, or on additional participating platforms, to serve as part of the Lookout Team for all acoustic, explosive, and physical disturbance and strike stressor mitigation categories (Navy 2024c). During AFTT Phase III, additional personnel were required to assist Lookouts for explosive events only. The Action Proponents have also clarified that AFTT Phase IV aircraft operating at high altitudes (i.e., greater than 15,000 ft) are exempt from requirements to conduct activity-based mitigation. When operating at high altitudes, observations for marine mammals or sea turtles would not be effective.

Mitigation Specific to Acoustic Stressors, Explosives, and Non-Explosive Ordnance

The mitigation measures described below will be implemented (as appropriate) in response to an applicable sighting within or entering the relevant mitigation zone for acoustic stressors, explosives, and non-explosive practice munitions:

- Prior to the initial start of an event (or stressor use), the Action Proponents will: (1) relocate the event to a location where applicable species are not observed, or (2) delay the initial start of the event (or stressor use) until one of the “Mitigation Zone All-Clear Conditions” has been met.
- During the event (i.e., during use of a stressor) the Action Proponents will (until one of the Mitigation Zone All-Clear Conditions has been met): (1) power down or shut down active acoustic transmissions, (2) cease air gun use, (3) cease pile driving or pile removal, (4) cease weapon firing or ordnance deployment, (5) or cease explosive detonations or fuse initiations (Navy 2024c).

Mitigation Zone All-Clear Conditions indicate that the mitigation zone is determined to be free of applicable species. The conditions include: (1) a Lookout observes the applicable species exiting the mitigation zone, (2) a Lookout determines the applicable species has exited the mitigation zone based on its observed course and speed relative to the mitigation zone, (3) a Lookout affirms the mitigation zone has been clear from additional sightings for an applicable “wait period,” or (4) for mobile events, the stressor has transited a distance equal to double the mitigation zone size beyond the location of the last sighting. Wait periods were established because events cannot be delayed or ceased indefinitely for the purpose of mitigation due to impacts on safety, sustainability, and the ability to meet mission requirements (Navy 2024c).

For AFTT Phase IV the Action Proponents added or modified several requirements for activity-based mitigations. Mitigation zones for broadband sources, which were not included in AFTT 2018 Final EIS/OEIS, have been added for this consultation. A 200 yard (yd) shut down mitigation zone will apply to broadband and other active acoustic sources less than 200 decibel (dB), while the tiered 1,000 yd power down/500 yd power down/200 yd shut down mitigation zones will apply to those sources greater than or equal to 200 dB (Navy 2024c). This requirement is meant to encompass new acoustic sources (e.g., sources used for oceanographic and acoustic research) that use a range of frequencies. In addition, the air gun mitigation zone

size has been increased from 150 yd to 200 yd for consistency with other active acoustic sources (Navy 2024c). AFTT Phase IV also includes new activity-based mitigation requirements for applicable events that involve Unmanned Surface Vehicles (USVs) and Unmanned Underwater Vehicles (UUVs; and the sources they use, tow, or deploy) that are already being escorted and operated under positive control by a manned surface vessel (Navy 2024c). New requirements are in place for “research-based sub-surface explosives” to account for new explosive events with research applications (e.g., acoustic and oceanographic research) that would use 0.1 pound (lb) to 5 lb net explosive weight (NEW).

Activity-based mitigation will not apply for acoustic stressor sources that are: 1) not operated under positive control; 2) used for navigation safety; 3) from aircraft operating at high altitudes; 4) from unmanned platforms except when escort vessels are already participating in the event; 5) used by submerged submarines; 6) de minimis; 7) unattended sources, such as moored buoys used for acoustic and oceanographic research; 8) in use when marine mammals (e.g., dolphins) are determined to be intentionally swimming at the bow or alongside or directly behind the vessel, vehicle, or device; and 9) above 2 kilohertz (kHz) for sea turtles (Navy 2024c).

Mitigation will not apply to explosives: 1) deployed by aircraft operating at high altitudes; 2) deployed by submerged submarines, except for explosive torpedoes; 3) deployed against aerial targets; 4) during vessel-launched missile or rocket events; 5) used at or below the de minimis threshold; and 6) deployed by unmanned platforms except when escort vessels are already participating in the event and have positive control over the explosive (Navy 2024c). Mitigation will not apply to non-explosive ordnance deployed: 1) by aircraft operating at high altitudes; 2) against aerial targets; 3) during vessel-launched missile or rocket events; and 4) by unmanned platforms except when escort vessels are already participating in the event and have positive control over ordnance deployment.

Additional details on the activity-based mitigation requirements for acoustic stressors, explosive stressors, and non-explosive ordnance are described in Table 5, Table 6, and Table 7, respectively.

Table 5. Activity-based Mitigation for Acoustic Stressors

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
Active Acoustic Sources				
- Active acoustic sources with power down and shut down capabilities: - Low-frequency active sonar ≥ 200 dB - Mid-frequency active sonar sources that are hull mounted on a surface ship (including surfaced submarines) - Broadband and other active acoustic sources > 200 decibels (dB)	200 yd from active acoustic sources (shut down) 500 yd from active acoustic sources (power down of 10 dB total) 1,000 yd from active acoustic sources (power down of 6 dB total)	- One Lookout in/on one of the following: - Aircraft - Pierside, moored, or anchored vessel - Underway vessel with space/crew restrictions (including small boats) - Underway vessel already participating in the event that is escorting (and has positive control over sources used, deployed, or towed by) an unmanned platform - Two Lookouts on an underway vessel without space/crew restrictions - Lookouts would use information from passive acoustic detections to inform visual observations when passive acoustic devices are already being used in the event	- Immediately prior to the initial start of using active acoustic sources (e.g., while maneuvering on station), observe for: - Marine mammals - Sea turtles (for sources < 2 kHz) - Floating vegetation - During use of active acoustic sources, observe for: - Marine mammals - Sea turtles (for sources < 2 kHz)	10 or 30 minutes (depending on fuel constraints of the platform)
- Active acoustic sources with shut down (but not power down) capabilities: - Low-frequency active sonar < 200 dB - Mid-frequency active sonar sources that are not hull mounted on a surface ship (e.g., dipping sonar, towed arrays) - High-frequency active sonar - Air guns - Broadband and other active acoustic sources < 200 dB	200 yd from active acoustic sources (shut down)			
Pile Driving and Pile Removal				
Vibratory and impact pile driving and removal	100 yd from piles being driven or removed (cease pile driving or removal)	- One Lookout on one of the following: - Shore - Pier - Small boat	15 minutes prior to the initial start of pile driving or pile removal, observe for: - Marine mammals - Sea turtles - Floating vegetation - During pile driving or removal, observe for: - Marine mammals - Sea turtles	15 minutes
Weapon Firing Noise				
Explosive and non-explosive large-caliber gunnery firing noise (surface-to-surface and surface-to-air)	30° on either side of the firing line out to 70 yd from the gun muzzle (cease fire)	One Lookout on a vessel	- Immediately prior to the initial start of large-caliber gun firing (e.g., during target deployment), observe for: - Marine mammals - Sea turtles - Floating vegetation - During large-caliber gun firing, observe for: - Marine mammals - Sea turtles	30 minutes

Table 6. Activity-based Mitigation for Explosive Stressors

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
Explosive Bombs				
Any NEW	2,500 yd from the intended target (cease fire)	One Lookout in an aircraft	- Immediately prior to the initial start of bomb delivery (e.g., when arriving on station), observe for: - Marine mammals - Sea turtles - Floating vegetation - During bomb delivery, observe for: - Marine mammals - Sea turtles - After the event, when practical, observe the detonation vicinity for dead or injured: - Marine mammals - Sea turtles - If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	10 minutes
Explosive Gunnery				
- Air-to-surface medium-caliber - Surface-to-surface medium-caliber	200 yd from the intended impact location (cease fire) 600 yd from the intended impact location (cease fire)	One Lookout on a vessel or in an aircraft	- Immediately prior to the initial start of gun firing (e.g., while maneuvering on station), observe for: - Marine mammals - Sea turtles	10 or 30 minutes (depending on fuel constraints of the platform)

• Surface-to-surface large-caliber	• 1,000 yd from the intended impact location (cease fire)		– Floating vegetation • During gunnery firing, observe for: – Marine mammals – Sea turtles • After the event, when practical, observe the detonation vicinity for dead or injured: – Marine mammals – Sea turtles • If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	
Explosive Line Charges				
• Any NEW	• 900 yd from the detonation site (cease fire)	• One Lookout on a vessel	• Immediately prior to the initial start of detonations (e.g., while maneuvering on station), observe for: – Marine mammals – Floating vegetation – Sea turtles • During detonations, observe for: – Marine mammals – Sea turtles • After the event, when practical, observe the detonation vicinity for dead or injured: – Marine mammals – Sea turtles • If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	• 30 minutes

Mitigation Category	Mitigation Zones	Mitigation Requirements	Mitigation Requirement Timing	Wait Period
Explosive Mine Countermeasure and Neutralization (No Divers)				
• 0.1–5 lb. NEW	• 600 yd from the detonation site (cease fire)	• One Lookout on a vessel or in an aircraft	• Immediately prior to the initial start of detonations (e.g., while maneuvering on station; typically, 10 or 30 minutes depending on fuel constraints), observe for: – Marine mammals – Sea turtles – Floating vegetation • During detonations or fuse initiation, observe for: – Marine mammals – Sea turtles • After the event, observe the detonation vicinity for 10 or 30 minutes (depending on fuel constraints) for dead or injured: – Marine mammals – Sea turtles • If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	• 10 or 30 minutes (depending on fuel constraints of the platform)
• >5 lb. NEW	• 2,100 yd from the detonation site (cease fire)	• Two Lookouts: one on a small boat and one in an aircraft		
Explosive Mine Neutralization (With Divers)				
• 0.1–20 lb. NEW (positive control)	• 500 yd from the detonation site (cease fire)	• Two Lookouts in two small boats (one Lookout per boat), or one small boat and one rotary-wing aircraft (with one Lookout each)	• Time-delay devices will be set not to exceed 10 minutes • Immediately prior to the initial start of detonations or fuse initiation for positive control events (e.g., while maneuvering on station) or for 30 minutes prior for time-delay events, observe for: – Marine mammals – Sea turtles – Manta rays – Hammerhead sharks – Floating vegetation • During detonations or fuse initiation, observe for: – Marine mammals – Sea turtles	• 10 or 30 minutes (depending on fuel constraints of the platform)

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
• 0.1–20 lb. NEW (time-delay) • >20–60 lb. NEW (positive control)	• 1,000 yd from the detonation site (cease fire)	• Four Lookouts in two small boats (two Lookouts per boat), and one additional Lookout in an aircraft if used in the event	– Manta rays – Hammerhead sharks • When practical based on mission, safety, and environmental conditions: – Boats will observe from the mitigation zone radius mid-point – When two are used, boats will observe from opposite sides of the mine location – Platforms will travel a circular pattern around the mine location – Boats will have one Lookout observe inward toward the mine location and one observe outward toward the mitigation zone perimeter – Divers will be part of the Lookout Team • After the event, observe the detonation vicinity for 30 minutes for dead or injured: – Marine mammals – Sea turtles – Manta rays – Hammerhead sharks • If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	
Explosive Missiles and Rockets				
• 0.6–20 lb. NEW (air-to-surface)	• 900 yd from the intended impact location (cease fire)	• One Lookout in an aircraft	• Immediately prior to the initial start of missile or rocket delivery (e.g., during a fly-over of the mitigation zone), observe for: – Marine mammals – Sea turtles – Floating vegetation • During missile or rocket delivery, observe for: – Marine mammals – Sea turtles • After the event, when practical, observe the detonation vicinity for dead or injured: – Marine mammals – Sea turtles • If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	• 10 or 30 minutes (depending on fuel constraints of the platform)
• >20–500 lb. NEW (air-to-surface)	• 2,000 yd from the intended impact location (cease fire)			

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
Explosive Sonobuoys and Research-Based Sub-Surface Explosives				
- Any NEW of sonobuoys 0.1–5 lb. NEW for other types of sub-surface explosives used in research applications	600 yd from the device or detonation site (cease fire)	- One Lookout on a small boat or in an aircraft - Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations	- Immediately prior to the initial start of detonations (e.g., during sonobuoy deployment, which typically lasts 20 to 30 minutes, observe) for: - Marine mammals - Sea turtles - Floating vegetation - During detonations, observe for: - Marine mammals - Sea turtles - After the event, when practical, observe the detonation vicinity for dead or injured: - Marine mammals - Sea turtles - If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	10 or 30 minutes (depending on fuel constraints of the platform)
Explosive Torpedoes				

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
Any NEW	2,100 yd from the intended impact location (cease fire)	- One Lookout in an aircraft - Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations	- Immediately prior to the initial start of detonations (e.g., during target deployment), observe for: - Marine mammals - Sea turtles - Floating vegetation - Jellyfish aggregations - During torpedo launches, observe for: - Marine mammals - Sea turtles - Jellyfish aggregations - After the event, when practical, observe the detonation vicinity for dead or injured: - Marine mammals - Sea turtles - If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	10 or 30 minutes (depending on fuel constraints of the platform)

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
Ship Shock Trials				
Any NEW	3.5 NM from the target ship hull (cease fire)	On the day of the event, 10 observers (Lookouts and third-party observers combined), spread between aircraft or multiple vessels as specified in the event-specific mitigation plan	- The Navy will develop a detailed event-specific monitoring and mitigation plan in the year prior to the event and provide it to NMFS for review - Beginning at first light on days of detonation, until the moment of detonation (as allowed by safety measures), observe for: - Marine mammals - Sea turtles - Floating vegetation - Jellyfish aggregations - Large schools of fish - Flocks of seabirds - If an incident involving a marine mammal or sea turtle is observed after an individual detonation, the Navy will follow established incident reporting procedures and halt any remaining detonations until the Navy can consult with NMFS and review or adapt the event-specific mitigation plan, if necessary - During the 2 days following the event at a minimum and up to 7 days at a maximum, and as specified in the event-specific mitigation plan, observe the detonation vicinity for dead or injured: - Marine mammals - Sea turtles - If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	30 minutes

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
SINKEX				
Any NEW	2.5 NM from the target ship hull (cease fire)	- Two Lookouts: one on a vessel and one in an aircraft - Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations	- During aerial observations for 90 minutes prior to the initial start of weapon firing, observe for: - Marine mammals - Sea turtles - Floating vegetation - Jellyfish aggregations - From the vessel during weapon firing, and from the aircraft and vessel immediately after planned or unplanned breaks in weapon firing of more than 2 hours, observe for: - Marine mammals - Sea turtles - Observe the detonation vicinity for 2 hours after sinking the vessel or until sunset, whichever comes first, for dead or injured: - Marine mammals - Sea turtles - If a marine mammal is visibly injured or killed as a result of detonation, explosives use in the event shall be suspended immediately and established incident reporting procedures shall be followed.	30 minutes

Table 7. Activity-based Mitigation for Non-Explosive Ordnance

<i>Mitigation Category</i>	<i>Mitigation Zones</i>	<i>Mitigation Requirements</i>	<i>Mitigation Requirement Timing</i>	<i>Wait Period</i>
Non-Explosive Aerial-Deployed Mines and Bombs				
• Non-explosive aerial-deployed mines • Non-explosive bombs	• 1,000 yd from the intended target (cease fire)	• One Lookout in an aircraft	• Immediately prior to the initial start of mine or bomb delivery (e.g., when arriving on station), observe for: – Marine mammals – Sea turtles – Floating vegetation • During mine or bomb delivery, observe for: – Marine mammals – Sea turtles	• 10 minutes
Non-Explosive Gunnery				
• Non-explosive surface-to-surface large-caliber ordnance • Non-explosive surface-to-surface and air-to-surface medium-caliber ordnance • Non-explosive surface-to-surface and air-to-surface small-caliber ordnance	• 200 yd from the intended impact location (cease fire)	• One Lookout on a vessel or in an aircraft	• Immediately prior to the initial start of gun firing (e.g., while maneuvering on station), observe for: – Marine mammals – Sea turtles – Floating vegetation • During gunnery firing, observe for: – Marine mammals – Sea turtles	• 10 or 30 minutes (depending on fuel constraints of the platform)
Non-Explosive Missiles and Rockets				
• Non-explosives (air-to-surface)	• 900 yd from the intended impact location (cease fire)	• One Lookout in an aircraft	• Immediately prior to the start of missile or rocket delivery (e.g., during a fly-over of the mitigation zone), observe for: – Marine mammals – Sea turtles – Floating vegetation • During missile or rocket delivery, observe for: – Marine mammals – Sea turtles	• 10 or 30 minutes (depending on fuel constraints of the platform)

Mitigation Specific to Vessels, Vehicles, and Towed In-Water Devices

For ship classes required to maintain more than one Lookout, the specific requirement is subject to change over time in accordance with the applicable navigation instruction, such as the Surface Ship Navigation Department Organization and Regulations Manual. The Action Proponents will notify NMFS should their Lookout policies change, including in the Surface Ship Navigation Department Organization and Regulations Manual.

Mitigation will be implemented to the maximum extent practical based on the prevailing circumstances, including consideration of safety of vessels, unmanned vehicles, towing platforms, and crews, as well as maneuverability restrictions (Navy 2024c). Mitigation will not be implemented (1) by submerged submarines, (2) by unmanned vehicles except when escort vessels are already participating in the event and have positive control over the unmanned vehicle movements, (3) when marine mammals (e.g., dolphins) are determined to be intentionally swimming at the bow, alongside the vessel or vehicle, or directly behind the vessel or vehicle (e.g., to bow-ride or wake-ride), (4) when pinnipeds are hauled out on man-made navigational structures, port structures, and vessels, and (5) when impractical based on mission requirements (e.g., during certain aspects of amphibious exercises) (Navy 2024c). Additional details on the activity-based mitigation requirements for vessels, unmanned vehicles, and towed in-water devices are described in Table 8.

Navy Lookouts will monitor the mitigation zones around underway USVs as mission and circumstances allow. These circumstances include, but are not limited to, the Lookout's location on the deck, the surface support vessel's position relative to the USV, the size of the USV, and the other responsibilities of the Lookout, such as monitoring the surface support vessel's mitigation zone and safe operation of the surface support vessel (Navy 2024a).

New Mitigation Measure for Cetacean Live Strandings or Near-shore Atypical Milling Events

The proposed action includes a requirement for cetacean live stranding or near-shore atypical milling events. In the event of a cetacean live stranding (or near-shore atypical milling) event within the AFTT Study Area or within 50 km (27 NM) of the boundary of the AFTT Study Area, where the NMFS Stranding Network is engaged in herding or other interventions to return animals to the water, NMFS OPR will advise the Action Proponents of the need to implement shutdown procedures for all active acoustic sources or explosive devices within 50 km of the stranding. Following this initial shutdown, NMFS will communicate with the Action Proponents to determine whether circumstances support modification of the shutdown zone. The Action Proponents may decline to implement all or part of the shutdown if the holder of the LOA, or his/her designee, determines that it is necessary for national security. Shutdown procedures for live stranding or milling cetaceans include the following:

- If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, NMFS will immediately advise that the shutdown around the animals' location is no longer needed;

- Otherwise, shutdown procedures will remain in effect until NMFS determines and advises that all live animals involved have left the area (either of their own volition or following an intervention); and
- If further observations of the marine mammals indicate the potential for re-stranding, additional coordination will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

Table 8. Activity-based Mitigation for Vessels, Vehicles, and Towed In-Water Devices

<i>Mitigation Category</i>	<i>Lookouts</i>	<i>Mitigation Zones and Requirements</i>
Manned Surface Vessels		
• Manned surface vessels, including surfaced submarines	• One or more Lookouts on manned underway surface vessels in accordance with the most recent navigation safety instruction	• Immediately prior to manned surface vessels getting underway and while underway, the Lookout(s) will observe for: – Marine mammals – Sea turtles • Underway manned surface vessels will maneuver themselves (which may include reducing speed) to maintain the following distances as mission and circumstances allow: – 500 yd from whales – 200 yd from other marine mammals – Vicinity of sea turtles
Unmanned Vehicles		
• Unmanned Surface Vehicles and Unmanned Underwater Vehicles already being escorted (and operated under positive control) by a manned surface support vessel	• One Lookout on a surface support vessel that is already participating in the event, and has positive control over the unmanned vehicle	• Immediately prior to unmanned vehicles getting underway and while underway, the Lookout will observe for: – Marine mammals – Sea turtles • A surface support vessel that is already participating in the event, and has positive control over the unmanned vehicle, will maneuver the unmanned vehicle (which may include reducing its speed) to ensure it maintains the following distances as mission and circumstances allow: – 500 yd from whales – 200 yd from other marine mammals – Vicinity of sea turtles
Towed In-Water Devices		
• In-water devices towed by an aircraft, a surface support vessel, or an Unmanned Surface Vehicle or Unmanned Underwater Vehicle already being escorted (and operated under positive control) by a manned surface vessel	• One Lookout on the manned towing vessel or aircraft, or on a surface support vessel that is already participating in the event and has positive control over an unmanned vehicle that is towing an in-water device	• Immediately prior to and while in-water devices are being towed, the Lookout will observe for: – Marine mammals – Sea turtles • Manned towing platforms, or surface support vessels already participating in the event that have positive control over an unmanned vehicle that is towing an in-water device, will maneuver itself or the unmanned vehicle (which may include reducing speed) to ensure towed in-water devices maintain the following distances as mission and circumstances allow: – 250 yd from marine mammals – Vicinity of sea turtles

Geographic Mitigation Areas

The Action Proponents will implement mitigation measures within specified areas to avoid potential impacts to ESA-listed species and their habitats. Mitigation areas are particular geographic locations within the action area where the Action Proponents will implement additional avoidance and minimization measures (Figure 1). The mitigation applies year-round unless specified otherwise. Should national security require the Action Proponents to exceed the limit of an activity within a mitigation area (e.g., sonar hours), personnel conducting the event would be required to obtain approval through the chain of command prior to commencement of the applicable event. The Action Proponents would provide NMFS with advance notification and include relevant information about the event (e.g., sonar hours, use of explosives) in their annual training and testing activity reports (Navy 2024c).

The Action Proponents considered several factors when determining the location of proposed geographic mitigation areas. First, they evaluated whether the mitigation area will be effective in reducing impacts to resources of biological or ecological importance. Next, they assessed how and to what degree implementation of mitigation measures will be compatible with planning, scheduling, and conducting proposed military readiness activities. A more thorough discussion of the factors used by the Action Proponents to determine which areas to propose for geographic mitigation is provided in Chapter 5 Mitigation of the AFTT Phase IV FEIS/OEIS (Navy 2024c).

Seafloor Resource Mitigation Areas

The Action Proponents propose to implement mitigation to avoid and minimize impacts to seafloor resources from explosives, physical disturbance, and strike stressors in mitigation areas throughout the action area. Mitigation will help to avoid or reduce impacts from explosives, physical disturbance, and strike stressors on seafloor resources, and consequently to any ESA-listed resources that inhabit, shelter, rest, feed, or occur in the mitigation areas.

To aid in the implementation of seafloor resource mitigation, the Action Proponents will include maps of the best available georeferenced data (i.e., where the available data accurately indicate the natural boundary of a seafloor resource and are not generalized within large geometric areas, such as large grid cells) in the PMAP for shallow-water coral reefs, artificial reefs, live hard bottom, and shipwrecks (Navy 2024c). For mitigation purposes, the term “live hard bottom” is defined as substrate in the marine environment with a covering of biotic features (e.g., seaweed, sponges, and hard corals).

A summary of the mitigation requirements for the following seafloor resource mitigation areas is shown in Table 9 through Table 12, respectively: Shallow-Water Coral Reef Mitigation Area; Artificial Reef, Live Hard Bottom, Submerged Aquatic Vegetation, and Shipwreck Mitigation Area; Key West Range Complex Seafloor Mitigation Area; and South Florida Ocean Measurement Facility Seafloor Mitigation Area.

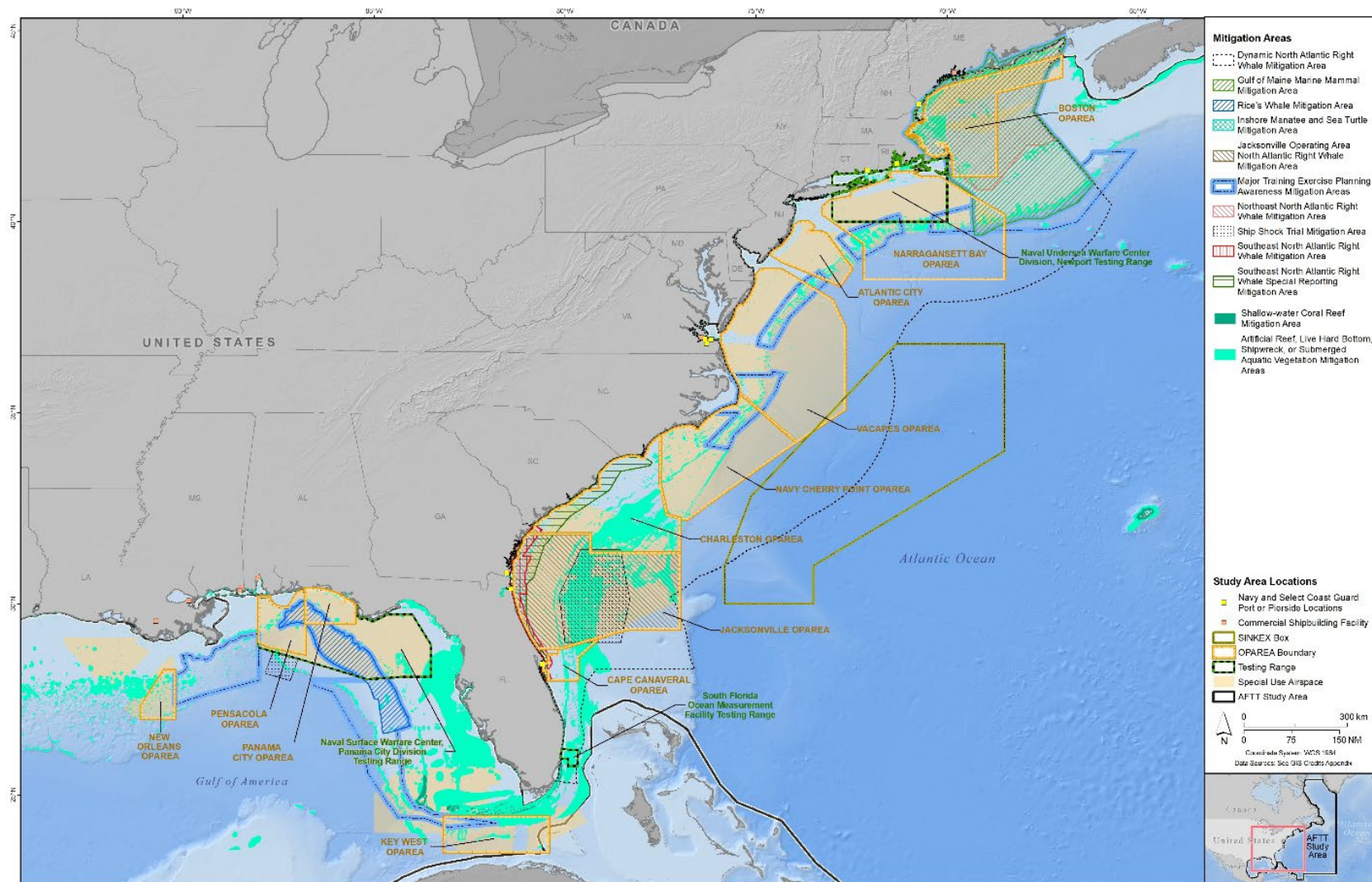


Figure 1. AFTT Geographic Mitigation Areas

Table 9. Shallow-Water Coral Reef Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Explosives	The Action Proponents will not detonate any in-water explosives (including underwater explosives and explosives deployed against surface targets) within a horizontal distance of 350 yd from shallow-water coral reefs.	The 350-yd mitigation area radius for in-water explosives was designed to be several times larger than the impact footprint (e.g., crater and expelled material radius) of the largest bottom-laid explosive (i.e., 650 lb. NEW mine) used in the action area. The mitigation is designed to prevent direct impacts (and some level of indirect impacts) from explosives on shallow-water coral reefs in the action area.
Physical disturbance and strike	- The Action Proponents will not set vessel anchors within the anchor swing circle radius from shallow-water coral reefs (except in designated anchorages). - The Action Proponents will not place non-explosive seafloor devices within a horizontal distance of 350 yd from shallow-water coral reefs (except as described in the bullet above for vessel anchors, and in Table 13 for the South Florida Ocean Measurement Facility Seafloor Mitigation Area). - The Action Proponents will not deploy non-explosive ordnance against surface targets (including aerial-deployed mines) within a horizontal distance of 350 yd from shallow-water coral reefs.	- The anchor swing circle mitigation is designed to ensure that vessel anchors do not come into contact with shallow-water coral reefs when factoring in environmental conditions that could affect anchoring position, such as winds, currents, and water depth. - The 350-yd mitigation area radius is designed to prevent direct impacts (and some level of indirect impacts) from seafloor devices (e.g., anchors, anchoring systems, mine-like objects, and bottom-crawling unmanned underwater vehicles) and non-explosive ordnance deployed against surface targets on shallow-water coral reefs.

Table 10. Artificial Reef, Live Hard Bottom, Submerged Aquatic Vegetation, and Shipwreck Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Explosives	The Action Proponents will not detonate explosives on or near the seafloor (e.g., explosive bottom-laid or moored mines) within a horizontal distance of 350 yd from artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks, except in designated locations where these resources will be avoided to the maximum extent practical (e.g., Truman Harbor, Demolition Key)	The 350-yd mitigation area radius is designed to prevent direct impacts (and some level of indirect impacts) from explosives on artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks.
Physical disturbance and strike	The Action Proponents will not set vessel anchors within the anchor swing circle radius from artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks (except in designated anchorages).	The anchor swing mitigation is designed to prevent vessel anchors from coming into contact with artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks, when factoring in environmental conditions that could affect anchoring position, such as winds, currents, and water depth.

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
	- The Action Proponents will not place non-explosive seafloor devices (that are not precisely placed) within a horizontal distance of 350 yd from artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks (except as described in the bullet above for vessel anchors, the bullet below for precisely placed seafloor devices, and in Table 13 for the South Florida Ocean Measurement Facility). - The Action Proponents will not position precisely placed non-explosive seafloor devices directly on artificial reefs, live hard bottom, submerged aquatic vegetation, or shipwrecks. - The Action Proponents will avoid positioning precisely placed non-explosive seafloor devices near these resources by the largest distance that is practical to implement based on mission requirements.	- The 350-yd mitigation area radius is designed to prevent direct impacts (and some level of indirect impacts) from seafloor devices and non-explosive ordnance deployed against surface targets on shallow-water coral reefs. - The mitigation for precisely placed non-explosive seafloor devices is new for AFTT Phase IV. This mitigation is designed to prevent direct impacts (and some level of indirect impacts) from seafloor devices on artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks.

Table 11. Key West Range Complex Seafloor Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Physical disturbance and strike	The Action Proponents will operate surface vessels in waters deep enough to avoid bottom scouring or prop dredging, with at least a 1-foot clearance between the deepest draft of the vessel (with the motor down) and the seafloor at mean low water.	- The mitigation area is bound by the 30-meter (m) depth contour, consistent with the deepest potential seagrass depth within the Key West Range Complex. - The mitigation is designed to ensure that surface vessels and propellers do not contact the seafloor or seafloor resources. - The mitigation is designed to protect the critical ecosystem functions of submerged aquatic vegetation and shallow soft bottom, shallow-water coral reefs, artificial reefs, live hard bottom, and shipwrecks at their known locations in the Key West Range Complex. - The mitigation is also designed to protect organisms (e.g., invertebrates, fishes, sea turtles) associated with these seafloor resources for sheltering, resting, feeding, or other important life processes.

Table 12. South Florida Ocean Measurement Facility Seafloor Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Physical disturbance and strike	- The Action Proponents will operate surface vessels in waters deep enough to avoid bottom scouring or prop dredging, with at least a 1-foot clearance between the deepest draft of the vessel (with the motor down) and the seafloor at mean low water. - The Action Proponents will use a real-time geographic information system and global positioning system (along with remote-sensing verification) during deployment, installation, and recovery of anchors and mine-like objects and during deployment of bottom-crawling	- The mitigation is designed to ensure that surface vessels, propellers, and seafloor devices do not contact the seafloor or certain seafloor resources. - The mitigation is designed to protect the critical ecosystem functions, socioeconomic

Category	Mitigation Requirements	Mitigation Details
	unmanned underwater vehicles in waters deeper than 10 ft to avoid shallow-water coral reefs and live hard bottom. • Surface vessels deploying seafloor devices will aim to hold a relatively fixed position over the intended mooring or deployment location using a dynamic positioning navigation system with global positioning system. • The Action Proponents will minimize surface vessel movement and drift (including anchor dragging) in accordance with mooring installation and deployment plans, and will conduct activities during sea and wind conditions that allow vessels to maintain position and speed control during deployment, installation, and recovery of seafloor devices. • The Action Proponents will not anchor surface vessels or moor over shallow-water coral reefs or live hard bottom. • The Action Proponents will use semi-permanent anchoring systems that are assisted with riser buoys over soft bottom habitats to avoid contact of mooring cables with shallow-water coral reefs and live hard bottom.	value, and cultural importance of submerged aquatic vegetation and shallow soft bottom, shallow-water coral reefs, artificial reefs, and live hard bottom at their known locations. • The mitigation is also designed to protect organisms (e.g., invertebrates, fishes, sea turtles) associated with these seafloor resources for sheltering, resting, feeding, or other important life processes.

Nearshore and Inshore Mitigation Areas for Sturgeon and Sea Turtles

As discussed above in the preceding tables, some of the seafloor resource mitigation area requirements may provide both direct and indirect benefits to ESA-listed sea turtles and sturgeon. In addition to these, the Action Proponents have proposed to implement mitigation in nearshore and inshore areas off North Carolina and Florida (Atlantic coast and northwestern panhandle) that are utilized by sea turtles and sturgeon for sheltering, resting, feeding, or other important life processes.

The North Carolina Sandbar Shark and Sea Turtle Mitigation Area requirements (Table 13) limit the use of explosives within 3.2 NM of an estuarine inlet and within 1.6 NM of the North Carolina shoreline in the Navy Cherry Point Range Complex. The Panama City Gulf Sturgeon and Sea Turtle Mitigation Area requirements (Table 14) apply from the shoreline out to the 30-m depth contour within the Naval Surface Warfare Center, Panama City Division Testing Range. The Inshore Manatee and Sea Turtle Mitigation Area requirements (Table 15) apply to the pierside use of active sonar at Naval Submarine Base Kings Bay and Port Canaveral, Florida, and vessel movements within inshore waters of Naval Submarine Base Kings Bay and Naval Station Mayport, Florida (Navy 2024c). Changes to the Inshore Manatee and Sea Turtle Mitigation Area for AFTT Phase IV include: 1) A reduction in the number of Lookouts required during pierside use of active sonar at Naval Submarine Base Kings Bay and Port Canaveral, Florida (from four to two) due to space restrictions; 2) Removal of the requirement for Lookouts to wear polarized sunglasses in the mitigation area; and 3) Clarification that relevant sightings at Naval Submarine Base Kings Bay will be reported to Port Operations.

Table 13. Nearshore North Carolina Sandbar Shark and Sea Turtle Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Explosives	From March 1 to September 30, the Action Proponents will not detonate explosive mines during mine neutralization events involving divers, and will avoid detonating all other types of in-water explosives (including underwater explosives and explosives deployed against surface targets) to the maximum extent practical.	Mitigation is designed to avoid exposure of in-water explosives on ESA-listed green, Kemp's ridley, loggerhead, and leatherback sea turtles during transit to and from nesting beaches. Nesting season typically lasts in this area from April to September for green and loggerhead sea turtles, and from March to September for leatherback sea turtles.

Table 14. Panama City Gulf Sturgeon and Sea Turtle Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Explosives	- From March 1 to September 30, the Action Proponents will not conduct line charge testing at night. - From March 1 to September 30, the Action Proponents will avoid conducting line charge testing in nearshore areas off of beaches with known sea turtle nesting, to the maximum extent practical and as mission allows. - From October 1 to March 31, the Action Proponents will not conduct line charge testing (except within a designated location on Santa Rosa Island).	- Mitigation to not conduct line charge testing at night from March 1 to September 30 is designed to avoid exposure of ESA-listed green, Kemp's ridley, loggerhead, and leatherback sea turtles to explosives during the time of day when individuals are most likely to transit to and from nesting beaches. - Mitigation to avoid conducting line charge testing in nearshore areas off of beaches with known sea turtle nesting is designed to minimize impacts of this activity on ESA-listed sea turtle reproductive behaviors. - Mitigation to not conduct line charge testing (day or night) from October through March (except within a designated location on Santa Rosa Island) is designed to avoid exposure of ESA-listed Gulf sturgeon during seasonal migrations from the Gulf of America winter and feeding grounds to the spring and summer natal (spawning) grounds in the Yellow, Choctawhatchee, and Apalachicola Rivers.

Table 15. Inshore Manatee and Sea Turtle Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Acoustic	- Pierside at Naval Submarine Base Kings Bay, the Action Proponents will reduce mid-frequency active sonar transmissions by at least 36 dB from full power. - The Action Proponents will conduct pierside active sonar activities during daylight hours at Port Canaveral, Florida, and Naval Submarine Base Kings Bay. - The Action Proponents will notify the Port Authority prior to commencing pierside active sonar activities at Port Canaveral, Florida, and Naval Submarine Base Kings Bay.	- Mitigation for active pierside sonar activities at Port Canaveral, Florida, and Naval Submarine Base Kings Bay are collectively designed to decrease potential impacts on manatees and sea turtles. - Mitigation to conduct pierside sonar activities during daylight hours at Port Canaveral, Florida, and Naval Submarine Base Kings Bay will help increase the likelihood that Lookouts will detect manatees and sea turtles. - Mitigation to implement a 36-decibel reduction from full power for pierside mid-frequency

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
	• The Action Proponents will post two Lookouts to conduct visual observations (who will follow applicable procedures described in Section 2.3.2 Activity-based Mitigation) during pierside active sonar activities at Port Canaveral, Florida, and Naval Submarine Base Kings Bay. After completion of pierside active sonar activities, Lookouts will observe for marine mammals and sea turtles for 30 minutes. • Pierside at Naval Submarine Base Kings Bay, the Lookout will communicate sightings of manatees and sea turtles (e.g., time, location, count, animal size, description of research tags if present, and direction of travel) during or within 30 minutes after pierside active sonar activities to Port Operations. Port Operations will record, report, or communicate relevant sightings information as required by the Integrated Natural Resource Management Plan.	active sonar transmissions at Naval Submarine Base Kings Bay, will reduce the level of sound exposure that would potentially be received by marine mammals and sea turtles, which would reduce the potential for injurious impacts at this location. • Mitigation for Lookouts to communicate information on sightings of manatees and sea turtles to Port Operations at Naval Submarine Base Kings Bay will assist sightings communication between platforms.
Physical disturbance and strike	• When underway in the St. Johns River or in the turning basins, channels, and waterways adjacent to Naval Station Mayport, vessels will comply with Federal, state, and local Manatee Protection Zones and reduce speed in accordance with established operational safety and security procedures. • When mooring pierside at Naval Submarine Base Kings Bay, submarines will ensure proper fendering techniques to remain off the quay wall.	• Mitigation for underway vessels to comply with Federal, state, and local Manatee Protection Zones will decrease the potential for interactions between vessels and manatees in the St. Johns River and within the waters of and adjacent to Naval Station Mayport. • Mitigation for fendering techniques is designed to prevent submarines from injuring or confining a manatee against the quay wall.

Ship Shock Trial Mitigation Area

Ship shock trials involve a series of underwater detonations that propagate a shock wave through a ship's hull under deliberate and controlled conditions. The potential impacts from ship shock trials to ESA-listed species are large (Madhusudhana et al. 2024) since this activity uses the largest NEW of any explosive activity conducted under the proposed action (Navy 2024c). As such, the Action Proponents have proposed to conduct ship shock trials only within established ship shock trial boxes within the Gulf Range Complex and overlapping the Jacksonville OPAREA. The boundaries of the mitigation areas match the boundaries of each ship shock trial box. For AFTT Phase IV, the Action Proponents repositioned the ship shock trial box outside of the Rice's whale core distribution area (as shown in Figure 22), to an area off the Naval Surface Warfare Center, Panama City Division Testing Range's southern boundary.

Major Training Exercise Planning Awareness Mitigation Areas

Mitigation to prohibit or limit MTEs (i.e., Composite Training Unit Exercises and Sustainment/Task Force Exercises) within regional planning mitigation areas is collectively designed to reduce potential impacts from the high levels of active sonar use typically associated with these multi-day, multi-platform exercises (Navy 2024c). The mitigation areas are situated among

highly productive environments and persistent oceanographic features associated with up-welling, steep bathymetric contours, and canyons. The areas have high marine mammal densities, abundance, or concentrated use for feeding, reproduction, or migration.

Table 16. Ship Shock Trial Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Explosives	- The Action Proponents will reposition the northern Gulf Range Complex ship shock trial box so it is situated outside of the Rice's whale core distribution area identified by NMFS in 2019 (84 <i>Federal Register</i> 15446) and updated in 2021 (86 <i>Federal Register</i> 47022). - The Action Proponents will not conduct ship shock trials within the portion of the ship shock trial box that overlaps the Jacksonville OPAREA from November 15 through April 15. - Pre-event planning for ship shock trials will include the selection of one primary and two secondary sites (within one of the ship shock trial boxes) where marine mammal abundance is expected to be the lowest during an event, with the primary and secondary locations located more than 2 NM from the western boundary of the Gulf Stream for events planned within the portion of the ship shock trial boxes that overlap the Jacksonville OPAREA. - If the Action Proponents determine during pre-event visual observations that the primary site is environmentally unsuitable (e.g., continuous observations of marine mammals), it would evaluate the potential to move the event to one of the secondary sites in accordance with the event-specific mitigation and monitoring plan.	- Repositioning the ship shock trial box outside of the Rice's whale core distribution area will reduce potential exposure of Rice's whales to injurious levels of sound (Madhusudhana et al. 2024). - Mitigation to not conduct ship shock trials in the Jacksonville OPAREA from November 15 through April 15 is designed to avoid potential injurious and behavioral impacts on North Atlantic right whales during calving season. - Mitigation to consider marine mammal abundance during pre-event planning, prioritize locations more than 2 NM from the Gulf Stream, and evaluate the environmental suitability of the selected site based on pre-event observations, are collectively designed to reduce the number of individual marine mammals exposed, as well as the level of impact that could potentially be received by each animal.

Table 17. Major Training Exercise Planning Awareness Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Acoustic	Northeast: Within Major Training Exercise Planning Awareness Mitigation Areas located in the Northeast (i.e., the combined areas within the Gulf of Maine, over the continental shelves off Long Island, Rhode Island, Massachusetts, and Maine), the Action Proponents will not conduct any major training exercises. Mid-Atlantic: Within Major Training Exercise Planning Awareness Mitigation Areas located in the Mid-Atlantic (i.e., the combined areas off Maryland, Delaware, and North	- Mitigation for the Northeast planning areas (including in the Gulf of Maine) is designed to prevent major training exercises from occurring within North Atlantic right whale foraging critical habitat, across the shelf break in the northeast, on Georges Bank, and in areas that contain underwater canyons (e.g., Hydrographer Canyon). These locations (including within a portion of the Northeast Canyons and Seamounts National Marine Monument) have been associated with high occurrences of marine mammal feeding, abundance, or mating for ESA-listed sei, fin, and North Atlantic right whales. - Mitigation for the Mid-Atlantic planning areas is designed to limit the number of major training exercises that could occur within large swaths of shelf break that contain underwater
Explosive		
Physical disturbance and strike		

Category	Mitigation Requirements	Mitigation Details
Special reporting for the use of acoustics and explosives	Carolina), the Action Proponents will avoid conducting any major training exercises to the maximum extent practical, and will not conduct more than four major training exercises per year. If the Navy needs to conduct additional major training exercises for national security, it will provide NMFS with advance notification and include the information in any associated training activity or monitoring reports.	canyons or other habitats (e.g., Norfolk Canyon, part of the Cape Hatteras Special Research Area) associated with high marine mammal diversity in this region, including ESA-listed blue, fin, sei, and sperm whales. The planning areas also overlap North Atlantic right whale migration habitats.

North Atlantic Right Whale Mitigation Areas

The mitigation areas described below (Tables 18 through 23) were designed primarily to avoid or minimize impacts to endangered North Atlantic Right whales in concentrated use areas for important life functions, including feeding, reproduction, and migration. Depending on the location and timing, these requirements may also result in reduced impacts and conservation benefits to other ESA-listed species including other marine mammals, sea turtles, and fish.

The Northeast North Atlantic Right Whale Mitigation Area extent matches that of the North Atlantic right whale foraging critical habitat designated by NMFS in 2016 (81 Federal Register 4838) (Navy 2024c). The Southeast North Atlantic Right Whale Mitigation Area is designed to protect reproductive mothers, calves, and mother–calf pairs within North Atlantic right whale calving habitat, but only encompasses a portion of critical habitat Unit 2: Southeastern U.S. Calving Area, as depicted in Figure 6 below.

The Action Proponents participate in and sponsor the Early Warning System which helps vessels avoid North Atlantic right whales during training and testing activities. The Early Warning System is a comprehensive information exchange network dedicated to reducing the risk of vessel strikes to North Atlantic right whales off the southeast United States from all mariners (*i.e.*, military and non-military vessels). The Navy, U. S. Coast Guard, U.S. Army Corps of Engineers (USACE), and NMFS collaboratively sponsor daily aerial surveys from December 1 through March 31 (weather permitting) to observe for North Atlantic right whales from the shoreline out to approximately 30 to 35 NM offshore. Aerial surveyors relay sighting information to all mariners transiting within North Atlantic right whale calving habitat (see Table 22 for details).

Outside of the Southeast North Atlantic Right Whale Mitigation Area, the Action Proponents will rely on other sources of information, including NMFS’s Right Whale Slow Zones and Dynamic Management Areas (DMAs). Right Whale Slow Zones and DMAs are voluntary programs that provide maps and coordinates indicating areas where right whales have been

recently detected and notifying vessel operators to slow down to avoid right whales. Upon receiving sighting or detection information via Slow Zone or DMA notifications, or even before if information is received from Navy monitoring contractors or an acoustic detection, the information will be sent to the Navy’s U.S. Fleet Forces Maritime Operations Center where it is added to the Common Operating Picture (COP). All ships have the COP up on large screens in their Combat Information Centers (CIC), which is the central command hub where all the tactical information from radars, sonars, and other sensors is gathered, processed, and analyzed in real-time.

For AFTT Phase IV, the Action Proponents will make operators aware of WhaleMap. WhaleMap was designed to collate all available near real-time whale detections and survey effort in the North Atlantic Ocean from multiple sources (including the NARW Early Warning and Sightings Advisory Systems) and display the information in an accurate, user-friendly, and publicly accessible format (Johnson et al. 2021). The WhaleMap web address (whalemap.org) will be included in PMAP reports generated for activities occurring in the Dynamic North Atlantic Right Whale Mitigation Area. In addition to use for implementing mitigation requirements within NARW mitigation areas, the Action Proponents will use WhaleMap to obtain the latest sightings data for planning propulsion testing events. The Action Proponents will provide Lookouts the sightings data to help inform visual observations during propulsion testing.

In addition to the requirements in the North Atlantic right whale geographic mitigation areas shown below, the Action Proponents have agreed to the following adaptive management measure:

Within the first year of AFTT Phase IV implementation, the Action Proponents shall work collaboratively with the NMFS ESA Interagency Cooperation Division and the NMFS Permits and Conservation Division to: 1) analyze and discuss the application of new information from NMFS’s North Atlantic Right Whale Persistence Modeling efforts toward AFTT mitigation measures; 2) evaluate the practicability and conservation benefits of newly proposed mitigation measures and/or changes to existing measures based on information from the persistence models; and 3) implement any new mitigation measures or changes to existing measures that meet the Action Proponents’ Practicability Criteria and Sufficiently Beneficial requirements.

Table 18. Northeast North Atlantic Right Whale Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Acoustic	The Action Proponents will minimize the use of low-frequency active sonar, mid-frequency active sonar, and high-frequency active sonar in the mitigation area to the maximum extent practical.	Mitigation is designed to minimize exposure of North Atlantic right whales to sounds with potential for injury or behavioral impacts.

Explosives	• The Action Proponents will not detonate in-water explosives (including underwater explosives and explosives deployed against surface targets) within the mitigation area. • The Action Proponents will not detonate explosive sonobuoys within 3 NM of the mitigation area.	• Mitigation is designed to prevent exposure of North Atlantic right whales to explosives with potential for injury, mortality, or behavioral impacts.
Physical disturbance and strike	• The Action Proponents will not use non-explosive bombs within the mitigation area. • During non-explosive torpedoes events within the mitigation area: – The Action Proponents will conduct activities during daylight hours in Beaufort sea state 3 or less. – In addition to Lookouts required as described in Section 2.3.2 (Activity-based mitigation), the Action Proponents will post two Lookouts in an aircraft during dedicated aerial surveys, and one Lookout on the submarine participating in the event (when surfaced). Lookouts will begin conducting visual observations immediately prior to the start of an event. If floating vegetation or marine mammals are observed in the event vicinity, the event will not commence until the vicinity is clear or the event is relocated to an area where the vicinity is clear. Lookouts will continue to conduct visual observations during the event. If marine mammals are observed in the vicinity, the event will cease until one of the Mitigation Zone All-Clear Conditions has been met as described in Section 2.3.2 (Activity-based mitigation). – During transits and normal firing, surface ships will maintain a speed of no more than 10 knots; during submarine target firing, surface ships will maintain speeds of no more than 18 knots; and during vessel target firing, surface ship speeds may exceed 18 knots for brief periods of time (e.g., 10 to 15 minutes). • For vessel transits within the mitigation area: – The Action Proponents will conduct a web query or e-mail inquiry to the North Atlantic Right Whale Sighting Advisory System to obtain the latest sightings data prior to transiting the mitigation area. To the maximum extent practical, the Action Proponents will provide Lookouts the sightings data prior to standing watch. Lookouts will use that data to help inform visual observations during vessel transits. • Surface ships will implement speed reductions after observing a North Atlantic right whale, if transiting within 5 NM of a sighting reported to the North Atlantic Right Whale Sighting Advisory System within the past week, and when transiting at night or during periods of restricted visibility⁸.	• Mitigation to prohibit use of non-explosive bombs is designed to reduce the potential for North Atlantic right whales to be struck by non-explosive ordnance. • Mitigation to conduct non-explosive torpedo activities during daylight hours in Beaufort sea state 3 or less, and to post additional Lookouts from aircraft (and submarines, when surfaced), is designed to improve marine mammal sightability during visual observations. • Mitigation for vessels to obtain sightings information from the North Atlantic Right Whale Sighting Advisory System and implement speed reductions in certain circumstances is designed to reduce the potential for vessel strike.
Special reporting for the use of acoustics and explosives	• The Action Proponents will report the total annual hours and counts of active sonar and in-water explosives (including underwater explosives and explosives deployed against surface targets) used in the mitigation area in their training and testing activity reports submitted to NMFS.	• Special reporting requirements are designed to aid the Action Proponents and NMFS in continuing to analyze potential

⁸ The term “restricted visibility” means any condition in which visibility is restricted by fog, mist, falling snow, heavy rainstorms, sandstorms or any other similar causes.

		impacts of training and testing in the mitigation area.

Table 19. Gulf of Maine Marine Mammal Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Acoustic	The Action Proponents will not use more than 200 hours of surface ship hull-mounted mid-frequency active sonar annually within the mitigation area.	Mitigation is designed to reduce exposure of North Atlantic right whales to potentially injurious levels of sound from the type of active sonar with the highest source power used in the Study Area within foraging critical habitat designated by NMFS in 2016 (81 <i>Federal Register</i> 4838) and additional sea space southward over Georges Bank.
Special reporting for the use of acoustics and explosives	- The Action Proponents will report the total annual hours and counts of active sonar and in-water explosives (including underwater explosives and explosives deployed against surface targets) used in the mitigation area in their training and testing activity reports submitted to NMFS. - If the Navy needs to conduct more than 200 hours of hull-mounted mid-frequency active sonar per year for national security, it will provide NMFS with advance notification and include the information in any associated training activity or monitoring reports.	Special reporting requirements are designed to aid the Action Proponents and NMFS in continuing to analyze potential impacts of training and testing in the mitigation area.

Table 20. Jacksonville Operating Area North Atlantic Right Whale Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Acoustic	- From November 15 to April 15 within the mitigation area, prior to vessel transits or military readiness activities involving active sonar, in-water explosives (including underwater explosives and explosives deployed against surface targets), or non-explosive ordnance deployed against surface targets (including aerial-deployed mines), the Action Proponents will initiate communication with Fleet Area Control and Surveillance Facility, Jacksonville to obtain Early Warning System data. The facility will advise of all reported North Atlantic right whale sightings in the vicinity of planned vessel transits and military readiness activities. - Sightings data will be used when planning event details (e.g., timing, location, duration) to minimize interactions with North Atlantic right whales to the maximum extent practical. - To the maximum extent practical, the Action Proponents will provide Lookouts the	Mitigation is designed to minimize potential North Atlantic right whale vessel interactions and exposure to stressors with the potential for mortality, injury, or behavioral disturbance within the portions of the reproduction (calving) critical habitat designated by NMFS in 2016 (81 <i>Federal Register</i> 4838) and important migration habitat that overlaps the Jacksonville OPAREA.
Explosives		
Physical disturbance and strike		

Category	Mitigation Requirements	Mitigation Details
	sightings data prior to standing watch to help inform visual observations.	

Table 21. Southeast North Atlantic Right Whale Mitigation Area (Navy 2024c)

Category	Mitigation Requirements	Mitigation Details
Acoustic	- From November 15 to April 15 within the mitigation area, the Action Proponents will not use high-frequency active sonar; or low-frequency or mid-frequency active sonar except: - To the maximum extent practical, the Action Proponents will minimize use of (1) helicopter dipping sonar (a mid-frequency active sonar source) and (2) low-frequency or surface ship hull-mounted mid-frequency active sonar during navigation training or object detection.	Mitigation is designed to minimize exposure to levels of sound that have the potential to cause injurious or behavioral impacts.
Explosives	- From November 15 to April 15 within the mitigation area, the Action Proponents will not detonate in-water explosives (including underwater explosives and explosives deployed against surface targets). - From November 15 to April 15 the Action Proponents will not detonate explosive sonobuoys within 3 NM of the mitigation area.	Mitigation is designed to prevent exposure to explosives with the potential for injury, mortality, or behavioral disturbance.
Physical disturbance and strike	- From November 15 to April 15 within the mitigation area, the Action Proponents will not deploy non-explosive ordnance against surface targets (including aerial-deployed mines). - From November 15 to April 15 within the mitigation area, surface ships will minimize north-south transits to the maximum extent practical, and will implement speed reductions after they observe a North Atlantic right whale, if they are within 5 NM of an Early Warning System sighting reported within the past 12 hours, and at night and in restricted visibility. - From November 15 to April 15 within the mitigation area, the Action Proponents will not conduct vessel propulsion testing.	Mitigation is designed to prevent strikes by non-explosive ordnance, and to decrease the potential for vessel strikes (which could result in mortality or serious injury). North-south transit restrictions are designed to reduce the time ships spend in the highest seasonal occurrence areas to further decrease vessel strike risk.
Acoustic	From November 15 to April 15 within the mitigation area, prior to vessel transits or military readiness activities involving active sonar, in-water explosives (including underwater explosives and explosives deployed against surface targets), or non-explosive ordnance deployed against surface targets (including aerial-deployed mines), the Action Proponents will initiate communication with Fleet Area Control and Surveillance Facility, Jacksonville to obtain Early Warning System sightings data. The facility will	Mitigation is designed to minimize potential vessel interactions and exposure to stressors with the potential for mortality, injury, or behavioral disturbance.
Explosives		
Physical disturbance and strike		

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
	advise of all reported North Atlantic right whale sightings in the vicinity of planned vessel transits and military readiness activities. To the maximum extent practical, the Action Proponents will provide Lookouts the sightings data prior to standing watch to help inform visual observations.	
Special reporting for the use of acoustics and explosives	The Action Proponents will report the total annual hours and counts of active sonar and in-water explosives (including underwater explosives and explosives deployed against surface targets) used in the mitigation area from November 15 to April 15 in their training and testing activity reports submitted to NMFS.	Special reporting requirements are designed to aid the Action Proponents and NMFS in continuing to analyze potential impacts of training and testing in the mitigation area.

Table 22. Southeast North Atlantic Right Whale Special Reporting Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Special reporting for the use of acoustics and explosives	From November 15 to April 15, the Action Proponents will report the total annual hours and counts of active sonar and in-water explosives (including underwater explosives and explosives deployed against surface targets) used within the mitigation area in their training and testing activity reports submitted to NMFS.	- The mitigation area extent aligns with the boundaries of the North Atlantic right whale critical habitat for reproduction designated by NMFS in 2016 (81 <i>Federal Register</i> 4838). - Special reporting requirements are designed to aid the Action Proponents and NMFS in continuing to analyze potential impacts of training and testing in the mitigation area.

Table 23. Dynamic North Atlantic Right Whale Mitigation Area (Navy 2024c)

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Acoustic	- The applicable dates and locations of this mitigation area will correspond with NMFS' Dynamic Management Areas, which fluctuate throughout the year based on the locations and timing of confirmed North Atlantic right whale detections. - The Action Proponents will provide North Atlantic right whale Dynamic Management Area information (e.g., location and dates) to applicable assets transiting and training or testing in the vicinity of the Dynamic Management Area. The information will alert assets (and their Lookouts) to the possible presence of North Atlantic right whales in their vicinity.	- The mitigation area extent matches the boundary of the U.S. EEZ on the East Coast, which is the full extent of where Dynamic Management Areas could potentially be established year-round. NMFS manages the Dynamic Management Areas program off the U.S. East Coast with the primary goal of reducing the likelihood of North Atlantic right whale vessel strikes from all mariners. - Mitigation is designed to minimize potential North Atlantic right whale vessel interactions and exposure to acoustic stressors, explosives, and
Explosives		
Physical disturbance and strike		

Category	Mitigation Requirements	Mitigation Details
	– Lookouts will use the information to help inform visual observations during military readiness activities that involve vessel movements, active sonar, in-water explosives (including underwater explosives and explosives deployed against surface targets), or non-explosive ordnance deployed against surface targets in the mitigation area. • In PMAP reports generated in the Dynamic North Atlantic Right Whale Mitigation Area, Action Proponents will: – Provide the WhaleMap web address (whalemap.org) – Advise that risk of whale strike is increased after observing a North Atlantic right whale; when operating within 5 NM of a known sighting reported within the past 24 hours; within a NMFS-designated Seasonal Management Area, Dynamic Management Area, or Slow Zone; and when transiting at night or during periods of restricted visibility; and – Reinforce the requirement of the International Regulations for Preventing Collisions at Sea to at all times for ships to proceed at a safe speed, appropriate to prevailing circumstances and conditions, to avoid a collision with any sighted object or disturbance, including any marine mammal or sea turtle. • During Propulsion testing, to the maximum extent practical, Lookouts will be provided recent whalemap.org sightings data to help inform visual observations.	physical disturbance and strike stressors that have the potential to cause mortality, injury, or behavioral disturbance.

Martha's Vineyard North Atlantic Right Whale Mitigation Area

The Action Proponents will avoid conducting vessel propulsion testing events to the maximum extent practical within this new geographic mitigation area (see Figure 1) for AFTT Phase IV.

Rice's Whale Mitigation Area

Table 24 shows the geographic mitigation requirements related to active sonar and explosives use in the northeastern Gulf of America.

Table 24. Rice's Whale Mitigation Area (Navy 2024c)

Category	Mitigation Requirements	Mitigation Details
Acoustic	• The Action Proponents will not use more than 200 hours of surface ship hull-mounted	• Mitigation is designed to reduce exposure of individuals within the small and resident population of Rice's whales to potentially

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
	mid-frequency active sonar annually within the mitigation area.	injurious levels of sound by the type of active sonar with the highest source power used in the Study Area.
Explosives	• Except during mine warfare activities, the Action Proponents will not detonate in-water explosives (including underwater explosives and explosives deployed against surface targets) within the mitigation area. • The Action Proponents will not detonate explosive sonobuoys within 3 NM of the mitigation area.	• Mitigation is designed to reduce exposure of individuals within the small and resident population of Rice's whales to explosives that have the potential to cause injury, mortality, or behavioral disturbance.
Physical disturbance and strike	• The Action Proponents will avoid conducting vessel propulsion testing events in areas that overlap with the Rice's whale mitigation area, to the maximum extent practical. • The Action Proponents will issue an annual awareness message to Navy and Coast Guard vessels that routinely train or test in the vicinity of the Rice's Whale proposed critical habitat. The message will advise that risk of whale strike is increased when transiting through Rice's whale proposed critical habitat (i.e., within the 100 to 400 m isobaths), particularly at night or during periods of restricted visibility. The message will also reinforce the requirement of the International Regulations for Preventing Collisions at Sea to at all times for ships to proceed at a safe speed so that the vessel can take proper and effective action to avoid a collision with any sighted object or disturbance, including any marine mammal or sea turtle, and be stopped within a distance appropriate to the prevailing circumstances and conditions.	• Mitigation is designed to decrease the potential for Rice's whale vessel strikes (which could result in mortality or serious injury).
Special reporting for the use of acoustics and explosives	• The Action Proponents will report the total annual hours and counts of active sonar and in-water explosives (including underwater explosives and explosives deployed against surface targets) used in the mitigation area in their training and testing activity reports submitted to NMFS. • If the Navy needs to conduct more than 200 hours of surface ship hull-mounted mid-frequency active sonar for national security, it will provide NMFS with advance notification and include the information in any associated training activity or monitoring reports.	• Special reporting requirements are designed to aid the Action Proponents and NMFS in continuing to analyze potential impacts of training and testing in the mitigation area.

Demolition Key Queen Conch Mitigation Area

Table 25 shows the geographic mitigation requirements in Demolition Key to minimize the impacts to queen conch from limpet mine training activities.

Table 25. Demolition Key Queen Conch Mitigation Area

<i>Category</i>	<i>Mitigation Requirements</i>	<i>Mitigation Details</i>
Explosives	- Action Proponent Personnel involved in this activity will review training module to include: – how to identify a queen conch (adult and juvenile), – how to handle them, – survey protocols, and – relocation protocols. - Before the Activity: – Up to 24 hours prior to detonation, personnel will survey 50-yd radius from the detonation location. – If any conchs (adult or juvenile) are observed, they will be relocated¹ to the back side of Demolition Key, following temporary relocation guidance.	- The mitigation will ensure that impacts to queen conch are reduced. - The mitigation is designed to protect queen conch at their known locations surrounding Demolition Key.
Special reporting for explosives use	Action Proponents will report the number of events and number of conchs moved each year in the annual monitoring report.	

¹ The Navy will obtain a license to relocate marine species in state waters, if required.

2.4 Stressors Resulting from the Components of the Proposed Action

In this section, the direct or indirect modifications to the land, water, or air caused by an action are identified stressors. This section identifies all of the stressors that may affect ESA-listed species and designated or proposed critical habitat, as well as the sources of those stressors. Some stressors may have multiple sources. Likewise, multiple sources may combine to create a stressor that would not exist if only one of the sources were present. The following is a summarization of stressors that are reasonably certain to be caused by this action.

The stressors we expect to result from the proposed action that may affect ESA-listed species or critical habitat fall into one of the following six categories:

- **Acoustic** (sonar and other transducers; pile driving; vessel noise; aircraft noise; weapons noise; and air guns)
- **Explosives** (explosions in water, at the surface, and in air)
- **Energy** (in-water electromagnetic devices; high-energy lasers)
- **Physical disturbance and strikes** (vessels; 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)

2.4.1 Acoustic Stressors

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars and air guns), as well as incidental sources of broadband sound produced as a byproduct of vessel movement; aircraft transits; pile driving and removal; and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately (Section 2.4.2) from other acoustic sources due to their unique energetic characteristics.

Vessel Noise

Radiated noise from vessels varies depending on the nature, size, and speed of the ship. Action Proponent vessels (including ships and small craft) typically produce low-frequency, broadband underwater sound, though the exact level of noise produced varies by vessel type. Many military vessels incorporate quieting technology that other vessels (e.g., commercial ships) do not. Anti-submarine warfare platforms (such as guided missile destroyers and cruisers) and submarines make up a large part of Navy traffic but are designed to be quiet to minimize detection. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz and Filadelfo 2011). The average acoustic signature for a Navy vessel is 163 dB re 1 μ Pa, while the average acoustic signature for a commercial vessel is 175 dB re 1 μ Pa (Mintz and Filadelfo 2011).

In general, vessel noise resulting from the proposed action will be greatest in areas with the highest volume of Action Proponent vessel traffic. Navy vessel traffic in the action area is concentrated along the U.S. East Coast near port facilities, especially around and between the ports of Norfolk, Virginia and Jacksonville, Florida (Figure 2). Coast Guard vessel traffic is also concentrated along the U.S. East Coast near port facilities, especially around and between the ports of Boston, Massachusetts, Norfolk, Virginia, and Key West, Florida, as well as around Puerto Rico. Action Proponent vessel traffic in the Gulf of America portion of the action area is relatively low, compared to vessel traffic throughout much

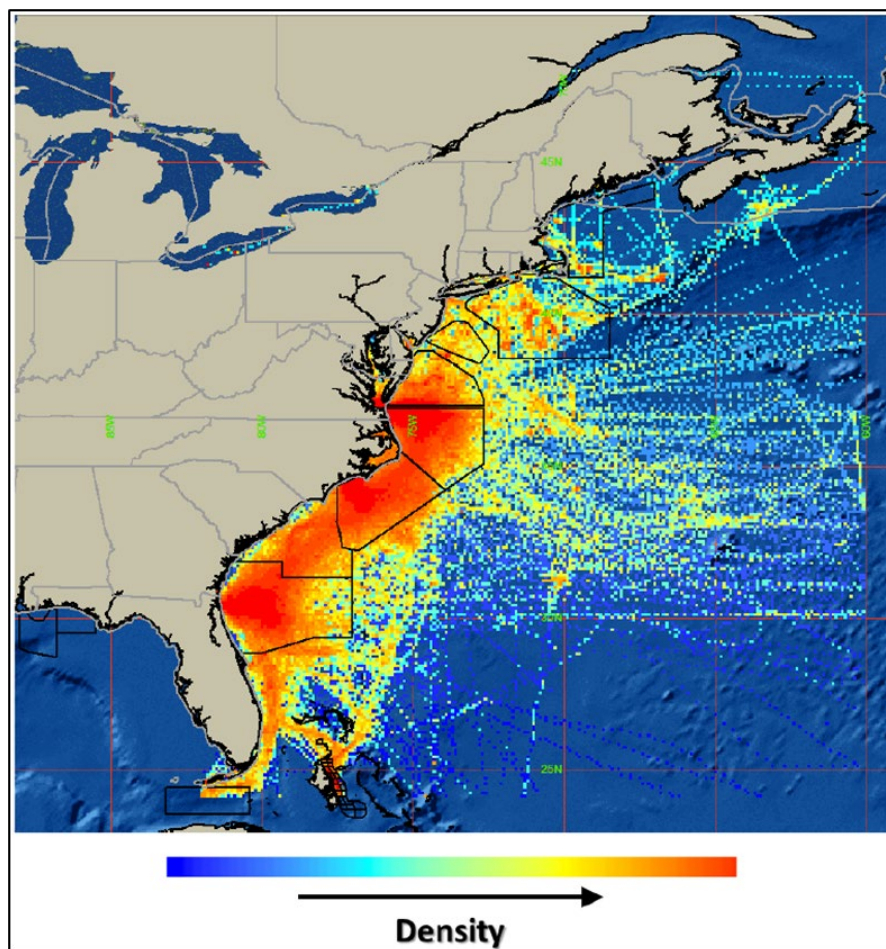


Figure 2. Relative Distribution of Navy Vessel Traffic in the Atlantic Coast Portion of the Action Area (Mintz 2016)

of the Atlantic Coast. Based on data from 2016-2023, 93% of the total AFTT military (i.e., Navy and Coast Guard) vessel traffic occurred within the Atlantic Coast portion of the action area (7% within the Gulf of America). For the Navy, 98% of the AFTT vessel traffic over this period occurred along the Atlantic Coast and 2% within the Gulf of America; for the Coast Guard 84% of the AFTT vessel traffic over this period occurred along the Atlantic Coast and 16% within the Gulf of America (Navy 2024a).

Action Proponent vessels represent about 1% of overall vessel traffic throughout the entire AFTT action area, and about 4% of overall vessel traffic within the military OPAREAs (Navy 2025a), as shown by the orange boxes in Figure 4 below (Section 3). These proportions are approximations, as it is difficult to directly compare military and non-military vessel activity based on the available information.

While commercial vessel traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Action Proponent traffic is more episodic in space and time. Vessels engaged in training and testing may consist of a single vessel involved in a unit-level activity for

a few hours or multiple vessels involved in a MTE that could last a few weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration. Action Proponent vessels do contribute to the overall increased ambient noise in inshore waters near military ports, although their contribution to the overall noise in these environments is a small percentage compared to the large volume of commercial and recreational vessel traffic in these areas (Mintz and Filadelfo 2011).

Aircraft Overflight Noise

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training and testing activities throughout the action area, contributing both airborne and underwater sound to the ocean environment. Aircraft used in training and testing generally have turboprop or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. Aircraft may transit to or from vessels at sea throughout the action area from established airfields on land. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 26 provides source levels for typical aircraft used during training and testing in the action area and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D during takeoff.

Table 26. Sound Characteristics of Representative Aircraft Proposed for AFTT

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

^{*} Estimate based on in-air level

Notes: dB re 1 μ Pa = decibel(s) referenced to 1 micropascal, dBA re 20 μ Pa = A-weighted decibel(s) referenced to 20 micropascal, AGL = Above Ground Level

Sources: ¹Eller and Cavanagh (2000), ²Bousman and Kufeld (2005), ³U.S. Department of the Air Force (2016)

Sound generated in air is transmitted to water primarily in a narrow area directly below the source. A sound wave propagating from any source must enter the water at an angle of incidence of about 13 degrees or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urlick 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 (i.e., sound would radiate out as a cone from the aircraft, with the area of transmission at the water surface being larger at increasing distances). As the sound source gains altitude, sound reaching the water surface diminishes, but the possible transmission area increases.

Fixed-wing Aircraft

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties (a flight mission made by an individual aircraft) would occur above 3,000 ft (Navy 2024c). 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) (Navy 2024c). Sound exposure levels (SEL) at the sea surface from most air combat maneuver overflights are expected to be less than 85 A-weighted dBs (based on an F/A-18 aircraft flying at an altitude of 5,000 ft and at a subsonic airspeed (400 knots; Navy 2017) (Navy 2024c). Kuehne et al. (2020) measured underwater noise levels at the end of the runway produced by Growler aircraft (EA-18G) immediately after take-off at Naval Air Station (NAS) Whidbey Island, WA. The average of the underwater received levels detected across all 10 overflights in the strongest 1-second window was 134 ± 3 dB re $1 \mu\text{Pa}$ at 30 m below the sea surface. The frequency of the sound from these overflights ranged from 20 Hz to 30 kHz, with a peak between 200 Hz and 1 kHz. While sound levels between the hydrophone and the surface may have been stronger than those measured at 30 m (Kuehne et al. 2020), this study only examined received levels from one focal point in the water column and did not model sound propagation to determine how noise from Growler overflights spreads throughout the water column.

Rotary-wing Aircraft

Noise generated from rotary-wing aircraft (e.g., helicopters) is transient in nature and extremely variable in intensity (Navy 2024c). The underwater noise produced by helicopters is estimated to be 125 dB re $1 \mu\text{Pa}$ at 1 m below water surface for an UH-60 hovering at 82 ft (25 m) altitude (Kufeld and M. 2005). Helicopter unit level training typically entails single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about two to four hours (Navy 2024c). Some events require low-altitude flights over a defined area, such as mine countermeasure activities deploying towed systems. Most helicopter sorties associated with mine countermeasures would occur at altitudes as low as 75 to 100 ft. Likewise, in some anti-submarine warfare events, a dipping sonar is deployed from a line suspended from a helicopter hovering at low altitudes over the water (Navy 2024c).

Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Several factors that influence the intensity of sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. Of all the factors influencing sonic booms, increasing altitude is the most effective method of

reducing the sonic boom intensity that is experienced at the sea or shore level. The width of the boom “carpet” or area exposed to a sonic boom beneath an aircraft is about 1 mile for each 1,000 ft of altitude (Navy 2024c). For example, an aircraft flying supersonic, straight, and level at 50,000 ft can produce a sonic boom carpet about 50 miles wide. 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 (Navy 2024c).

A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (Navy 2024c). Aircraft maneuvers that result in changes to acceleration, flight path angle, or heading can also affect the strength of a boom. In general, an increase in flight path angle (lifting the aircraft’s nose) will diffuse a boom while a decrease (lowering the aircraft’s nose) will focus it. In addition, acceleration will focus a boom while deceleration will weaken it. Any change in horizontal direction will focus or intensify a boom by causing two or more wave fronts that originated from the aircraft at different times to coincide exactly (Navy 2024c). Atmospheric conditions such as wind speed and direction, and air temperature and pressure can also influence the sound propagation of a sonic boom.

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 are difficult to detect at depths greater than 33 ft (10 m) (Sohn et al. 2000). F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels and energy flux density at the water surface and at depth (Laney and Cavanagh 2000). These results are shown in Table 27.

Table 27. Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight (Navy 2017)

Mach Number*	Aircraft Altitude (km)	Peak SPL (dB re 1 μ Pa)			Energy Flux Density (dB re 1 μ Pa ² -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.

Mach Number*	Aircraft Altitude (km)	Peak SPL (dB re 1 μ Pa)			Energy Flux Density (dB re 1 μ Pa ² -s) ¹		
		At surface	50 m Depth	100 m Depth	At surface	50 m Depth	100 m Depth

Notes: SPL = sound pressure level, dB re 1 μ Pa = decibel(s) referenced to 1 micropascal, dB re 1 μ Pa²-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s), km = kilometers

For the proposed action, supersonic aircraft flights are not intentionally generated below 30,000 ft (9.1 km) unless over water and more than 30 NM from inhabited coastal areas or islands (Navy 2024c). Deviation from these guidelines may occur for tactical missions that require supersonic flight, phases of formal training requiring supersonic speeds, research and test flights that require supersonic speeds, and for flight demonstration purposes when authorized by the Chief of Naval Operations (Navy 2024c). 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 (Navy 2024c).

Sonar and other Transducers

Sonars and other transducers are non-impulsive sources and include the following types of devices: submarine sonars, surface ship sonars, helicopter dipping sonars, torpedo sonars, active sonobuoys, acoustic countermeasures, mine hunting sonars, navigation sonars, underwater communications, tracking pingers, and UUVs and their associated sonars. Active sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. The proposed action includes the use of a variety of sonars and other transducers to obtain and transmit information about the undersea environment. Some examples are mid-frequency hull-mounted sonars used to find and track submarines; high-frequency small object detection sonars used to detect mines; high-frequency underwater modems used to transfer data over short ranges; and extremely high-frequency (greater than 200 kHz) Doppler sonars used for navigation, like those used on commercial and private vessels (Navy 2024c).

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. Anti-submarine warfare activities often use mid-frequency (1 to 10 kHz) active sonar, though low-frequency and high-frequency active sonar systems are also used for specialized purposes (Navy 2024c). Mine warfare military readiness activities use a variety of different sonar systems that are typically high-frequency (greater than 10 kHz) and very high-frequency (greater than 100 kHz).

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.

In the BA for this consultation, non-impulsive narrowband bins were grouped by their frequency category (low - LF, medium - MF, high - HF, or very high - VHF) and their source level category (low, medium, or high), resulting in 12 source categories, and broadband bins were grouped by the frequency categories they span (e.g., LF, LF to MF, etc.) (Navy 2024c). An additional category was added to represent the hull-mounted surface ship sonar (i.e., MF1). The sonar and transducer source categories and activity levels (i.e., hours or counts) for the proposed action are shown in Table 28.

Table 28. Sonar and Transducer Source Categories and Activity Levels (Navy 2024c)

Source Category	Description	Unit	Navy Training		Coast Guard Training		Testing	
			Annual	7-year Total	Annual	7-year Total	Annual	7-year Total
Broadband Sources								
LF	<205 dB	H	-	-	-	-	206-252	1,580
LF to MF		H	-	-	-	-	1,501-1,503	10,519
LF to HF		C	-	-	-	-	791-1,020	5,101
		H					2,367-2,571	16,356
MF to HF		C	133	931	-	-	-	-
		H	935-951	6,595	280	1,960	2,749-2,950	19,308
HF to VHF		H	10	70	-	-	-	-
Low-Frequency Acoustic Sources								
LFL	160 dB to 185 dB	H	-	-	-	-	1,969	13,783
LFM	185 dB to 205 dB	C	-	-	-	-	360	2,520
		H	746	5,219	-	-	5,386-6,106	39,862
LFH	>205 dB	C	1,920-2,020	13,760	-	-	6,078-6,084	42,588
		H	144	1,008	-	-	414-479	3,101
Mid-Frequency Acoustic Sources								
MFL	160 dB to 185 dB	H	-	-	-	-	3,238-3,582	22,336
MFM	185 dB to 205 dB	C	6,825-6,964	48,196	-	-	16,017-16,040	111,849
		H	2	14	-	-	3,081-3,509	23,012
MFH	>205 dB	H	2,343-2,466	16,794	-	-	7,203-7,943	52,542
High-Frequency Acoustic Sources								

Source Category	Description	Unit	Navy Training		Coast Guard Training		Testing	
			Annual	7-year Total	Annual	7-year Total	Annual	7-year Total
HFL	160 dB to 185 dB	H	169	1,183	-	-	96	672
HFM	185 dB to 205 dB	C	-	-	-	-	860-1,660	8,420
		H	1,253-1,255	8,777	210	1,470	4,125-4,489	29,941
HFH	>205 dB	C	138	966	-	-	1,621-1,858	11,684
		H	3,892-3,940	27,436	-	-	3,779-4,580	28,383
Very High-Frequency Acoustic Sources								
VHFL	160 dB to 185 dB	H	12	84	-	-	-	-
VHFM	185 dB to 205 dB	H	918	6,426	-	-	120	840
VHFH	>205 dB	C	-	-	-	-	69-103	520
		H	579	4,051	140	980	5,584	39,088
Hull-Mounted Surface Ship Sonar								
MF1C	Hull-mounted surface ship sonar with duty cycle >80% (previously MF11)	H	661-722	4,811	-	-	1,139	7,974
MF1K	Hull-mounted surface ship sonar in Kingfisher mode	H	280	1,957	-	-	108	759
MF1	Hull-mounted surface ship sonar	H	3,498-3,870	25,602	-	-	1,102-1,390	8,464

Notes: C = Count; H = Hours; - = Not Applicable

In addition to the sources described above, the proposed action involves sonar and transducer sources described by the Action Proponents as *de minimis*. De minimis sources include those with low source level, narrow beam width, downward-directed transmission, short pulse lengths, frequencies above known hearing ranges of ESA-listed species, or some combination of these factors, as well as sources used for the safety of navigation (Navy 2024c). Some examples include Doppler sonar/speed logs, fathometers, hand-held sonar, imaging sonar, high-frequency acoustic modems, tracking pingers, acoustic releases, and side-scan sonar.

Noise from Weapons

The Action Proponents train and test using a variety of weapons. Depending on the weapon, noise may be produced at launch or firing, while in flight, or upon impact. Other devices intentionally produce noise to serve as a non-lethal deterrent. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by explosives, both in air and water, are discussed in Section 2.4.2.

Noise associated with large caliber weapons firing and the impact of non-explosive practice munitions would typically occur at locations greater than 12 NM from shore for safety reasons. Small- and medium-caliber weapons firing could occur throughout the action area (Navy 2024c). Examples of some types of weapon noise are shown in Table 29.

Table 29. Examples of Noise from Weapons (Navy 2024c)

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

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

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

Firing a gun produces a muzzle blast in the air that propagates away from the gun with the strongest directivity in the direction of fire. As the pressure from the muzzle blast from a ship-mounted large caliber gun propagates in the air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. Most sound enters the water in a narrow cone beneath the sound source (about 13 to 14 degrees of vertical), with most sound outside of this cone being reflected from the water surface (Navy 2024c). 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 (Navy 2024c).

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 (Navy 2024c). The bow shock wave itself travels at the speed of

sound in air. Sound waves from a projectile in flight enters the water in a narrow cone beneath the sound source, with in-air sound being 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 (Navy 2024c).

Sound due to missile and target launches is typically at a maximum at the 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 (Navy 2024c).

Any object dropped in the water would create a noise upon impact, depending on the object's size, mass, and speed. Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. A significant portion of an object's kinetic energy would be lost to splash, any deformation of the object, and other forms of non-mechanical energy (McLennan 1997). The remaining energy could contribute to sound generation. Most objects would be only momentarily detectable, but some large objects traveling at high speeds could generate a broadband impulsive sound upon impact with the water surface. Sound associated with impact events is typically of low frequency (less than 250 Hz) and short duration (Navy 2024c).

Although not a weapon, the Long Range Acoustic Device (and other hailing and deterrent sources) is considered along with in-air sounds produced by Navy sources. The Long Range Acoustic Device is a communication device that can be used to warn vessels from continuing towards a high value asset by emitting loud sounds in air. The system would typically be used in training activities near shore, and use would be intermittent during these activities. Source levels at 1 m range between 137 dBA re 1 μ Pa for small portable systems and 153 dBA re 1 μ Pa for large systems (Navy 2024c). Sound would be directed within a 30 to 60° wide zone over open water.

Air Guns

Air guns are 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 (in³) would be used during testing activities in various offshore areas in the action area, as well as near shore at Newport, Rhode Island (Navy 2024c). Table 30 shows the number of air guns shots proposed in the action area.

Table 30. Number of Shots from Air Guns and Non-explosive Sources Proposed for Use in the Action Area (Navy 2024c)

<i>Source Class Category</i>	<i>Description</i>	<i>Unit</i>	<i>Training</i>		<i>Testing</i>	
			<i>Annual</i>	<i>7-Year Total</i>	<i>Annual</i>	<i>7-Year Total</i>
NEI	Non-explosive impulsive	C	-	-	192-240	1,488
AG	Air gun	C	-	-	4,400-5,400	33,800

Notes: C = Count

Generated impulses would have short durations, typically a few hundred milliseconds, with dominant frequencies below 1 kHz. The root mean square (RMS) sound pressure level (SPL) and peak pressure (SPL peak) at a distance 1 m from the air gun would be approximately 215 dB rms re 1 μ Pa and 227 dB_{peak} re 1 μ Pa, respectively, if operated at the full capacity of 60 in³ (Navy 2024c). The size of the air gun chamber can be adjusted smaller, which would result in a lower SPL and SEL per shot.

Pile Driving

Impact and vibratory pile driving and removal could occur during Expeditionary Warfare, Port Damage Repair training in Gulfport, Mississippi. The pile driving method, pile type and size, and the number of piles/sheets are presented in Table 31. Pile driving events would be conducted over five days, up to four times per year (20 days total) in the same port location each time. Per event, round timber or plastic piles would be installed using impact methods and round timber or plastic, and steel sheet piles would be installed using vibratory methods.

Regardless of pile type, full-power impact pile driving would incorporate a soft start procedure which may serve to “warn” nearby marine species and reduce the initial noise exposure (Navy 2024c). Only one hammer would be used at any given point in time; there would not be any instances where multiple piles would be driven simultaneously. Piles and sheets would be removed using the vibratory hammer. Timber or plastic piles could also be removed using a dead pull method.

Table 31. Number of Piles / Sheets Proposed During Pile Driving and Removal Training Activities (Navy 2024c)

<i>Method</i>	<i>Pile Size and Type</i>	<i>Number of Piles / Sheets</i>	
		<i>Annual</i>	<i>7-Year Total</i>
Impact ¹	16-inch Timber or Plastic Round Piles	80	560
Vibratory	16-inch Timber or Plastic Round Piles	160	1,120
Vibratory	27-inch Steel Sheet	240	1,680

¹ Installation only

Impact pile driving involves using an impact hammer, with both the hammer and the pile held in place by a crane. When the pile driving starts, the hammer part of the mechanism is raised 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 (Navy 2024c). Broadband impulsive signals are produced by impact pile driving methods, with most of the acoustic energy concentrated below 1,000 hertz (Hz) (Hildebrand 2009a). The Navy estimates that the impact pile driver would generally operate at an average of 60 strikes per minute, or 300 strikes per pile (Navy 2024c).

Vibratory installation and extraction would involve the use of a vibratory hammer 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, driving the pile into the sediment (Navy 2024c). During removal, the vibration causes the sediment particles in contact with the pile to lose frictional grip on the pile. In some cases, the crane may be able to lift the pile and vibratory driver without vibrations from the driver (dead pull), in which case no noise would be introduced into the water. Vibratory driving and removal create broadband, continuous, non-impulsive noise at low source levels, for a short duration with most of the energy dominated by lower frequencies (Navy 2024c).

Port Damage Repair training would occur in shallow 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 sandy bottom would absorb or attenuate the sound more readily than hard substrates (rock), which may reflect the acoustic wave (Navy 2024c).

The predicted sound levels produced by pile driving by method, pile size and type for Port Damage Repair training are presented in Table 32.

Table 32. Port Damage Repair Training Pile Driving and Removal Underwater Sound Levels (Navy 2024c)

<i>Method</i>	<i>Pile Size and Type</i>	<i>Unattenuated Levels</i>		
		<i>Peak SPL (dB re 1 μPa)</i>	<i>SEL (single strike; (dB re 1 μPa²:s)</i>	<i>RMS SPL (dB re 1 μPa)</i>
Impact ¹	16-inch Timber or Plastic Round Piles	180	160	170
Vibratory	25-inch Steel Sheets	-	-	159
Vibratory	16-inch Timber or Plastic Round Piles	-	-	162

¹ Installation only

2.4.2 Explosive Stressors

Explosive detonations used during AFTT military readiness activities include bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys.

Explosive detonations occur in the air or near the water's surface (e.g., bombs, missiles, and naval gun shells), in the water column (e.g., torpedoes, explosive sonobuoys, mines, demolition charges), and on the ocean bottom (e.g., mines and demolition charges).

When underwater explosions occur, they generate both primary blast waves and secondary effects including fragmentation of the explosive casing and surrounding materials. These fragments vary significantly in size and velocity depending on the type and size of explosive charge. Studies of underwater explosions have demonstrated that fragment characteristics follow predictable patterns of distribution, though exact fragment sizes and velocities can be difficult to measure in marine environments. The physical properties of these fragments, including their mass, shape, and initial velocity, play crucial roles in determining their potential for causing injury to marine species. Secondary stressors can also include sediment disturbance and displacement, which can result in increased turbidity and potential smothering of coral and other benthic invertebrates.

The weight of the explosive warhead and the type of explosive material greatly influence the effect of an explosive. In their BA, the Action Proponents categorize explosives that could detonate in water or at the water surface into bins based on their NEW. The NEW is the explosive power of a charge expressed as the equivalent weight of trinitrotoluene (Navy 2024c). Table 33 shows the number of explosives within each bin that could occur in any year (and over 7-years) for AFTT military readiness activities.

Table 33. Number of Explosives within Each Bin that Could Occur in Any Year (and over 7-years) for AFTT Phase IV Military Readiness Activities (Navy 2024c)

Bin	Net Explosive Weight Range (lbs)	Example Explosive Source	Navy Training		Coast Guard Training		Navy Testing	
			Annual	7-Year Total	Annual	7-Year Total	Annual	7-Year Total
E1	0.1–0.25	Medium-caliber projectile	3,002	21,014	-	-	1,825	12,775
E2	> 0.25–0.5	Medium-caliber projectile	60	420	-	-	-	-
E3	> 0.5–2.5	Large-caliber projectile	5,078	35,546	180	1,260	1,069-1,971	8,705
E4	> 2.5–5	Mine neutralization charge	82	574	-	-	2,893-4,687	30,889
E5	> 5–10	5 inch projectile	1,109	7,763	-	-	1,268-1,860	11,540
E6	> 10–20	Hellfire missile	508	3,556	-	-	17-25	125
E7	> 20–60	Demo block/ shaped charge	10	70	-	-	8-22	62
E8	> 60–100	Lightweight torpedo	20	140	-	-	10-13	41
E9	> 100–250	500 lb. bomb	138	966	-	-	5	35
E10	> 250–500	Harpoon missile	71	497	-	-	4	28
E11	> 500–675	650 lb. mine	1	7	-	-	1-2	8
E12	> 650–1,000	2,000 lb. bomb	20	140	-	-	-	-

Bin	Net Explosive Weight Range (lbs)	Example Explosive Source	Navy Training		Coast Guard Training		Navy Testing	
			Annual	7-Year Total	Annual	7-Year Total	Annual	7-Year Total
E16	> 7,250–14,500	Small ship shock trial	-	-	-	-	0-6	15

In addition to the sources described above, the proposed action involves very small impulsive sources (less than 0.1 lbs net explosive weight) in bin E0. Quantitative modeling in multiple locations has validated that these sources have a very small zone of influence. Since Bin E0 explosives are not anticipated to result in take of ESA-listed species, these sources are categorized as de minimis and are qualitatively analyzed.

Most explosive detonations would occur in waters greater than 200 ft in depth and greater than 3 NM from shore, although mine warfare, demolition, amphibious warfare, and some testing detonations could occur in shallow water close to shore (Navy 2024c). Details regarding the location and distance from shore for the proposed AFTT Phase IV activities involving explosives, categorized by bin type, can be found in the AFTT BA addendum (pp. 8-11), which we incorporate here by reference (Navy 2024c).

The propagation of explosive pressure waves in water is significantly influenced by various environmental factors, including bathymetry, bottom type, water depth, temperature, and salinity. These factors determine how pressure waves are reflected, refracted, or scattered, as well as the potential for reverberation and interference caused by multi-path propagation (Navy 2024c). Explosions in air produce an initial blast front that propagates away from the detonation. When pressure waves from an explosion in air meet the water surface, the pressure wave can be transmitted across the air-water boundary and reflected off the water surface. When pressure waves in air meet the water at a perpendicular angle (e.g., straight down from an in-air source to a flat-water surface), the sound waves are both transmitted directly across the water surface in the same direction of travel and reflected 180° back toward the original direction of travel (Navy 2024c).

Most explosions in air for the proposed action would occur far above the water surface at sufficient altitude that a large portion of the sound would refract upward due to cooling temperatures with increased altitude, and would not reach the water's surface (Navy 2024c). Typical air explosive munitions proposed for AFTT Phase IV, along with their NEW and typical detonation altitude, are shown in Table 34.

Table 34. Typical Air Explosive Munitions Proposed for AFTT Phase IV (Navy 2024c)

<i>Weapon Type¹</i>	<i>Net Explosive Weight (lb.)</i>	<i>Typical Altitude of Detonation (ft.)</i>
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 Caliber²		
5"54 HE-ET	7	< 100
5"54 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.

Notes: AMRAAM = Advanced Medium-Range Air-to-Air Missile; HARM = High-Speed Anti-Radiation; HE-ET = High Explosive- Electronic Time

2.4.3 Energy Stressors

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

In-Water Electromagnetic Devices

In-water electromagnetic energy devices include towed or unmanned mine warfare systems that simply mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic “pulse.” A mine neutralization device could be towed through the water by a surface vessel or remotely operated vehicle, emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship (Navy 2024c). The sound and electromagnetic signature cause nearby mines to detonate. Generally, the voltage used to power these systems is around 30 volts (Navy 2024c). The static magnetic field generated by the mine neutralization devices is of relatively minute strength (i.e., somewhere between a refrigerator magnet and a can opener) (Navy 2024c). The number and location of activities using in-water electromagnetic devices for the proposed action is provided

in Table 3.3-12 of the Action Proponents BA (Section 3.3.2.3.2, p. 3-28 to 3-29), which we incorporate here by reference (Navy 2024c).

High-energy Lasers

High-energy laser weapons training and testing involves using up to 30 kW of directed energy as a weapon against small surface vessels and airborne targets (Navy 2024c). 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 and the laser shuts off when it loses contact with the target (Navy 2024c).

The number and location of activities using high-energy lasers for the proposed action is provided in Table 3.3-13 of the Action Proponents BA (Section 3.3.2.3.2, p. 3-30), which we incorporate here by reference (Navy 2024c).

2.4.4 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors include vessels, in-water devices, military expended materials, and seafloor devices, each of which is described further in the sections below. Pile driving, which was discussed in Section 2.4.1 as an acoustic stressor, can also be a physical disturbance stressor resulting in impacts to ocean bottom sediment and water turbidity.

Vessels

Vessels used by the Action Proponents during training and testing activities include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 ft to over 1,000 ft. Large military ships (greater than 59 ft in length) generally operate at average speeds of between 10 and 15 knots, and submarines generally operate at speeds between 8 to 13 knots. Small craft (defined here as less than 50 ft in length), which are all support craft, have much more variable speeds, between 0 to 50+ knots, dependent on the mission.

The Action Proponents will also conduct propulsion testing as part of their AFTT activities involving vessels. This activity, which can involve ships operating at speeds over 30 knots, may pose a higher strike risk due to the high vessel speeds. Propulsion testing would occur in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf Range Complexes (which includes Atchafalaya Bay/River), as well as the Naval Surface Warfare Center Panama City Testing Range, and Gulf Range Complex Inshore. The proposed locations and annual number of propulsion testing events within the AFTT action area are shown in Figure 3. The distance from shore for this activity varies greatly depending on the vessel being tested, the scenario, and the program. The Action Proponents will not conduct propulsion testing in the Southeast North Atlantic Right Whale Mitigation Area, and will avoid conducting propulsion testing in the Martha's Vineyard North Atlantic Right Whale Mitigation Area and Rice's Whale Mitigation Area to the maximum extent practical (see Section 2.3.2 Geographic Mitigation Areas for details).

The ability of any vessel to detect a marine mammal or sea turtle and avoid a collision depends on a variety of factors, including environmental conditions, ship design, ship size, ship speed, and personnel, as well as the behavior of the animal involved. Table 35 provides examples of the types of vessels, lengths, and typical operating speeds for the AFTT proposed military readiness activities. The relative risk of a vessel strike is often assessed as a function of animal density and vessel traffic density (e.g., Fonnesebeck et al. 2008; Vanderlaan et al. 2008; Silber et al. 2021). Additional information on vessel traffic density throughout the action area can be found in Section 2.4.1 above.

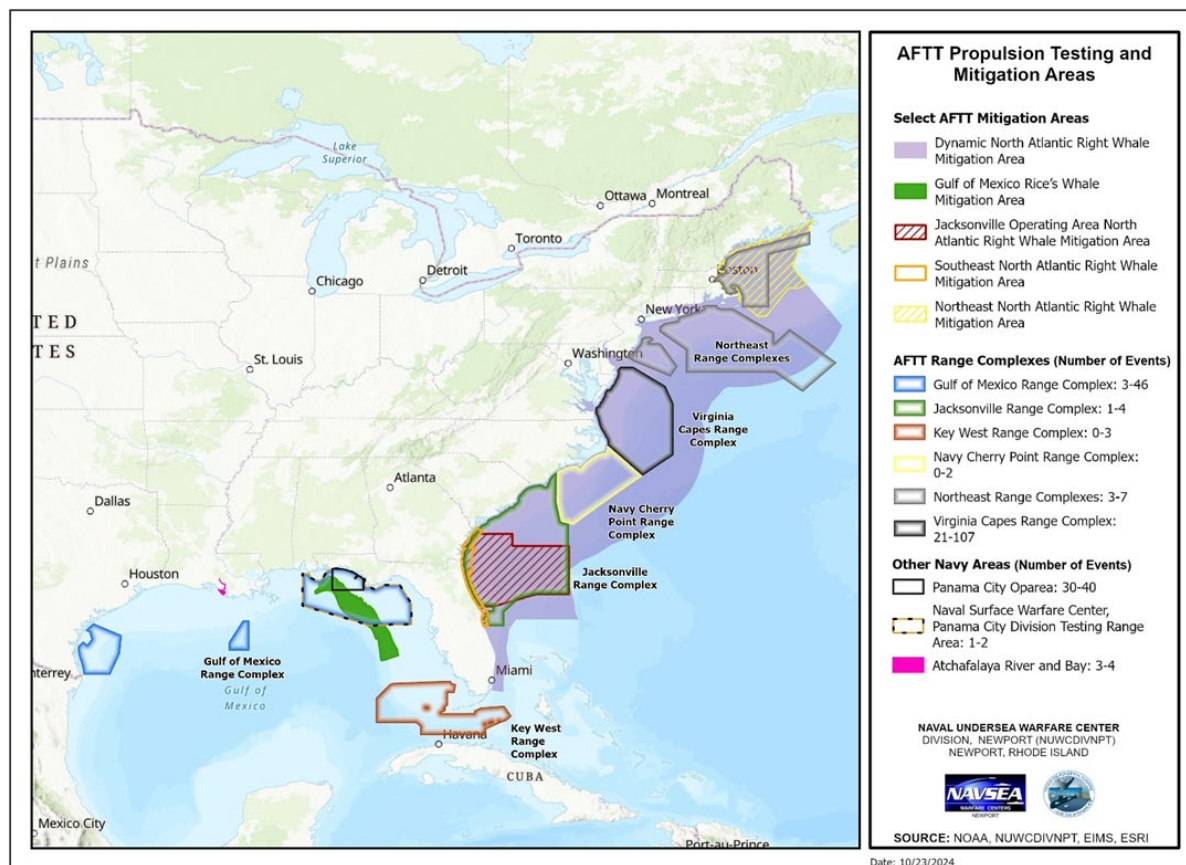


Figure 3. Proposed Locations and Annual Number of Propulsion Testing Events within the AFTT Action Area (Navy 2024a)

Table 35. Representative Vessel Types, Lengths, and Speeds (Navy 2024c)

<i>Navy and Marine Vessel Types</i>	<i>Example(s)</i>	<i>Length</i>	<i>Typical Operating Speed</i>
Aircraft Carrier	Aircraft Carrier (CVN)	>1000 ft	10–15 knots
Surface Combatant	Cruisers (CG), Destroyers (DDG), Frigates (FF) Littoral Combat Ships (LCS)	300–700 ft	10–15 knots
Amphibious Warfare Ship	Amphibious Assault Ship (LHA, LHD), Amphibious Transport Dock (LPD), Dock Landing Ship (LSD)	300–900 ft	10–15 knots

<i>Navy and Marine Vessel Types</i>	<i>Example(s)</i>	<i>Length</i>	<i>Typical Operating Speed</i>
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
<i>Coast Guard Vessel Types</i>			
Large cutters	Legend Class, Heritage Class, Famous Class, Juniper Class, Reliance Class	181–418 ft	0 to 30 knots
Small cutters	Keeper Class, Sentinel Class, Bay Class, Island Class, Marine Protector Class, Small Harbor Tug	66–180 ft	0 to 30 knots
Boats	Aid to Navigation Boats, Screening Vessels, Lifeboats, Response Boats, Training Boats, Long Range Interceptors, Law Enforcement Boats, Cutterboat Over the Horizon, Transportable Security Boats	13–65 ft	0 to 40 knots

In-Water Devices

In-water devices include unmanned vehicles, such as remotely operated vehicles, USVs, UUVs, motorized autonomous targets, and towed devices. These devices are self-propelled and unmanned or towed through the water from various platforms, including helicopters, UUVs, and surface ships. In-water devices are generally smaller than most Navy vessels, ranging from several inches to about 50 ft, although some USVs are up to 328 ft and some UUVs are up to 98 ft. These devices can operate anywhere from the water surface to the benthic zone.

Representative types, sizes, and speeds of in-water devices for the proposed action are shown in Table 36.

Military Expended Materials

Military expended materials that may cause physical disturbance or strike include: (1) all sizes of non-explosive practice munitions; (2) fragments from high explosive munitions; (3) expendable targets; and (4) expended materials other than munitions, such as sonobuoys or torpedo accessories (Navy 2024c). For details regarding the number and location of different types of military expended materials used in the proposed action see Section 3.3.2.4.2 (pp. 3-36 to 3-59) of the AFTT BA (Navy 2024c).

Seafloor Devices

Seafloor devices are items used during training or testing activities that are deployed onto the seafloor and subsequently recovered. These items include moored mine shapes, recoverable

anchors, bottom-placed instruments, and robotic vehicles referred to as “crawlers” (Navy 2024c). Seafloor devices are either stationary or move very slowly along the bottom.

Table 36. Representative Types, Sizes, and Speeds of In-Water Devices (Navy 2024c)

<i>Type</i>	<i>Example(s)</i>	<i>Length</i>	<i>Typical Operating Speed</i>
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	Up to 328 ft ¹	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	Up to 98 ft ¹	1–15 knots
Torpedoes	Light-weight and Heavy-weight Torpedoes	< 33 ft	20–30 knots

¹ The proposed unmanned surface vehicles for AFTT Phase IV range from 36 to 328 ft, and the proposed unmanned underwater vehicles range from 33 to 98 ft. There are also smaller unmanned vehicles proposed ranging approximately from 4 to 16 ft (Navy 2024a).

2.4.5 Entanglement Stressors

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

Wires and Cables

Fiber optic cables are expended during training and testing associated with remotely operated mine neutralization activities. Although a portion may be recovered, some fiber optic cables used during training and testing associated with remotely operated mine neutralization activities would be expended (Navy 2024c). The length of the expended tactical fiber would vary (up to 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 0.24 mm diameter, 12 lb. tensile strength, and 3.4 mm bend radius (Navy 2017; Navy 2024c). Tactical fiber is relatively brittle; it readily breaks if knotted, kinked, or abraded against a sharp object. The tactical fiber would be suspended within the water column during the activity, and then be expended and sink to the seafloor (effective sink rate of 1.45 centimeters [cm] per second where it would be susceptible to abrasion and burial by sedimentation (Navy 2024c).

Guidance wires are used during heavy-weight torpedo firings to help the firing platform control and steer the torpedo (Navy 2024c). The torpedo guidance wire is a single-strand, thin gauge, coated copper alloy with a maximum tensile breaking strength of 40.4 lbs (Swope and McDonald

2013). The wire trails behind the torpedo as it moves through the water and sinks to the ocean floor after it is released. Torpedo guidance wire sinks at a rate of 0.24 m per second (Swope and McDonald 2013).

Sonobuoys consist of a surface antenna and float unit and a subsurface hydrophone assembly unit. The two units are attached through a thin-gauge, dual-conductor, and hard-draw copper strand wire, which is then wrapped by hollow rubber tubing or a bungee in a spiral configuration. The tensile breaking strength of the wire and rubber tubing is no more than 40 lbs (Navy 2024c). 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. 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 (Navy 2024c).

Bathythermographs are similar to sonobuoys in that they consist of an antenna, a float unit, and a subsurface unit (to measure the 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 (Navy 2024c).

The number and location of wires and cables expended as part of the proposed action are provided in the AFTT BA (Section 3.3.2.5.1.3, Table 3.3-26, pp. 3-63 to 3-65), and are incorporated here by reference (Navy 2024c).

Decelerators and Parachutes

Decelerators and parachutes used during training and testing activities are classified into four different categories based on size: small, medium, large, and extra-large (Table 37). 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 inches in diameter (small). The majority of the decelerators/parachutes in the small size category are cruciform shaped and associated with sonobuoys (Navy 2024c). Both small- and medium-sized decelerators/parachutes are made of cloth and nylon, many with weights on their short attachment lines to speed their sinking. At water impact, the decelerator/parachute assembly is expended and sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Group 2005). Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Aerial targets (drones) use large and extra-large parachutes. Large and extra-large parachutes are also made of cloth and nylon, with suspension lines of varying lengths. Unlike the small- and medium-sized decelerators/parachutes, large and extra-large parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to

eventual settlement on the seafloor. Activities involving parachutes are proposed to occur within Range Complexes, which begin at 3 NM from shore, and the majorities of activities that use parachutes will typically occur even further offshore (at least 12-15 NM). Up to 80 extra-large parachutes will be used annually for testing, and up to 500 large parachutes will be used annually for testing and training. The majority of these (i.e., up to 44 extra-large and 318 large) will be deployed in the VACAPES RC, with the remainder distributed throughout multiple range complexes within the action area. The Action Proponents will attempt to retrieve large and extra-large parachutes on the surface, however they are not always successful due to logistics and safety concerns.

The area with the greatest concentration of small and medium expended decelerators/parachutes during training activities would be in the JAX Range Complex at 0.82 units per NM² per year. The area with the greatest concentration of large expended decelerators/parachutes would be in the Navy Cherry Point Range Complex at <0.01 units per NM² per year (Navy 2024c).

Table 37. Size Categories for Decelerators and Parachutes Expended During Training and Testing Activities (Navy 2024c)

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

Biodegradable Polymers

Marine vessel stopping activities proposed for AFTT include the use of biodegradable polymers that are designed to entangle or occlude the propellers of vessels in an attempt to significantly slow and potentially stop the advance of the vessel (Navy 2024c). The biodegradable polymers that the Navy uses are constructed from various amounts and configurations of polyvinyl alcohol, polylactic acid, sodium polyacrylate, ethylene vinyl alcohol copolymer, and protein based biopolymers. Biodegradable polymers degrade into smaller compounds as a result of microorganisms and enzymes present in the environment. Based on the constituents of the biodegradable polymers proposed for use in AFTT, it is anticipated that the material will break down into small pieces within a few days to weeks (Navy 2024c). These small pieces will break down further and dissolve into the water column within weeks to a few months. Degradation and dispersal times are influenced by water temperature, currents, and other oceanographic features.

2.4.6 Ingestion Stressors

The Action Proponents expend the following types of materials that could become ingestion stressors during training and testing: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including

plastic end caps and pistons), decelerators/parachutes, and biodegradable polymers (Navy 2024c).

Small- and medium-caliber projectiles range in size up to 2.25 inches diameter. Flechettes from some non-explosive rockets are approximately 2 inches long. Each non-explosive flechette rocket contains approximately 1,180 individual metal flechettes that are released. Many different types of high-explosive munitions and targets can result in fragments that are expended at sea during training and testing activities. Fragments would result from fractures in the munitions casing and would vary in size depending on the NEW and munition type. 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 (see AFTT BA, Table 3.3-29, pp. 3-69 to 3-70 for details on target numbers and locations). 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 would likely be too large for marine organisms to consume (Navy 2024c).

Solid metal materials, such as small-caliber projectiles or fragments from high-explosive munitions, are expected to sink rapidly to the seafloor. Lighter plastic items (e.g., plastic end caps from chaff cartridges or plastic pistons from flare cartridges) 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 (Navy 2024c).

Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff is released or dispensed from cartridges that contain millions of fibers. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al. 2002; Navy 2024c). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 miles from the point of release, with the plume covering more than 400 miles (Arfsten et al. 2002). 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 (Navy 2024c).

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 (Navy 2024c). The flare device consists of a cylindrical cartridge approximately 1.4 inches in diameter and 5.8 inches in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic compression pad or piston (0.45 to 4.1 grams depending on flare type). The flare pads and pistons float in sea water.

2.4.7 Other Stressors

Metals are introduced into seawater and sediments as a result of AFTT activities involving ship hulks, targets, munitions, and other military expended materials. Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. AFTT activities also introduce chemicals and explosive byproducts into the marine environment that are potentially harmful in higher concentrations. Chemicals introduced are principally from flares and propellants for missiles and torpedoes.

2.5 MMPA Regulations and Issuance of Letters of Authorization

On June 14, 2024, the Permits Division notified us that they had received an application from the Action Proponents requesting LOAs for the incidental taking of marine mammals during the conduct of training and testing activities in the western Atlantic Ocean along the east coast of North America, the Gulf of America, and portions of the Caribbean Sea. The application request was submitted for three LOAs: 1) a 7-year LOA for Navy training activities, 2) a 7-year LOA for Navy testing activities, and 3) a 7-year LOA for Coast Guard training activities. All three LOAs were requested for the years 2025-2032.

The Permits Division proposes to issue regulations pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the Action Proponents to “take” marine mammals incidental to AFTT military readiness activities. The regulations propose to authorize the issuance of LOAs that will allow the Action Proponents to “take” marine mammals incidental to their training and testing activities. Issuance of final regulations and related LOAs by the Permits Division is dependent on a determination that the total taking of the affected species or stocks of marine mammals over the 7-year period from the specified activity as a whole would have a negligible impact on the affected species or stocks. NMFS has defined negligible impact in 50 CFR §216.103 as “an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.”

The Permits Division’s proposed regulations, which include proposed mitigation, monitoring, and reporting requirements, are available on the following website:

<https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities>.

This consultation considers the proposed MMPA regulations for the Action Proponents to “take” marine mammals incidental to AFTT activities, as modified during ESA consultation. The final MMPA rule, upon publication, will also be available on the website shown above. Note that this opinion was completed prior to the publication of the final MMPA rule in the *Federal Register*. We anticipate that, upon publication, the MMPA rule will reflect the mitigation and monitoring measures proposed by the Action Proponents and/or agreed to during ESA consultation. A description of the mitigation measures for this consultation is in Section 2.3.2 of this opinion. We will also review mitigation measures imposed by the final regulations to ensure they are consistent with measures to avoid and minimize take prescribed in the ITS (Section 10). We also anticipate that the levels of take of

ESA-listed marine mammals authorized under the final MMPA rule and LOAs will be consistent with those analyzed in this opinion. Upon publication, we will review the MMPA rule to ensure these conditions are met. If administrative changes are needed following publication of the MMPA rule, we will update this opinion to reflect these changes. If more substantive changes (e.g., those related to the effects analyses, take authorization, and/or avoidance and minimization measures) are needed, the reinitiation triggers described in Section 12 may apply.

3 ACTION AREA

Action area means “all areas to be affected directly or indirectly by the Federal action, and not merely the immediate area involved in the action” (50 CFR §402.02). The action area is defined by the extent of the environmental changes the stressors cause on the physical environment (e.g., land, air or water, detailed in the previous section). The AFTT action area includes areas of the western Atlantic Ocean along the east coast of North America, the Gulf of America, and portions of the Caribbean Sea (Figure 4).

A Navy Range Complex consists of geographic areas that encompass a water component 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 operating areas and special use airspace, which may be further divided to provide better control of the area for safety reasons. 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 air traffic. Land components associated with the range complexes and testing ranges are not included in the action area, and no activities on these land areas are included as part of the proposed action. The action area begins at the mean high tide line along the U.S. coast and extends east to the 45 degree (°) west longitude line, north to the 65° north latitude line, and south to approximately the 20° north latitude line. It also includes Navy pierside locations, Coast Guard Stations, port transit channels, bays, harbors, inshore waterways, and civilian ports, as well as vessel and aircraft transit routes between homeports and OPAREAs.

A summary of the AFTT range complexes, and associated OPAREAs, is provided in Table 38. In addition to offshore areas, some of the range complexes include associated inshore water bodies, which are shown in Table 39. For a complete list of the Naval pierside locations, civilian ports, and Coast Guard Stations included in the action area we refer the reader to the AFTT BA (Section 2.1, p. 2-11), which we incorporate here by reference (Navy 2024c).

For more detailed maps highlighting particular regions (i.e., Northeast-Mid-Atlantic, Southeast, Gulf of America) or features (e.g., inshore locations, coastal zones, Coast Guard stations) within the action area, we refer the reader to the AFTT BA (Section 2.1, pp. 2-3 to 2-8), which we incorporate here by reference (Navy 2024c).

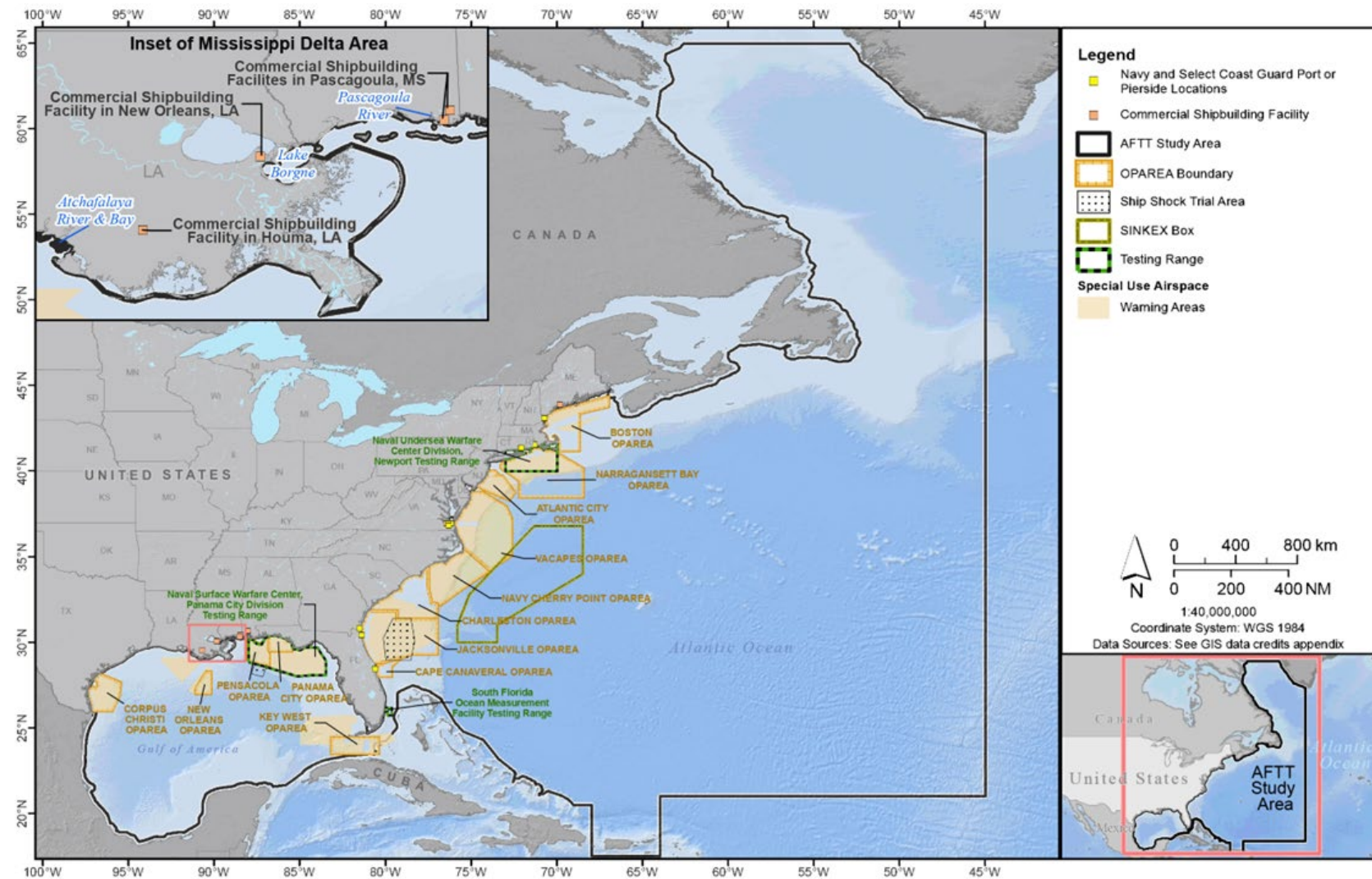


Figure 4. AFTT Action Area (Navy 2024c)

Table 38. Training and Testing Ranges included in the AFTT Action Area (Navy 2024c)

<i>Name</i>	<i>Basic Location</i>	<i>Sea and Undersea Space</i>	<i>Air Space</i>
Northeast Range Complexes	761 miles along the coast from Maine to New Jersey	46,000 NM ² of sea and undersea space Includes three OPAREAs: Boston, Narragansett Bay, and Atlantic City	29,000 NM ² of special use airspace
Naval Undersea Warfare Center Division, Newport Testing Range	Includes the waters of Narragansett Bay, Rhode Island Sound, Block Island Sound	11,000 NM ² of sea and undersea space Includes three Restricted Areas: Coddington Cove, Narragansett Bay, and Rhode Island Sound	Minimal testing occurs in airspace within the test area
VACAPES Range Complex	270 miles along the coast from Delaware to North Carolina, from the shoreline to 155 NM seaward	30,000 NM ² of sea and undersea space Includes one OPAREA: Virginia Capes	29,000 NM ² of special use airspace
Navy Cherry Point Range Complex	Off the coast of North and South Carolina, from the shoreline to 120 NM seaward	19,000 NM ² of sea and undersea space Includes one OPAREA: Cherry Point	19,000 NM ² of special use airspace
JAX Range Complex	520 miles along the coast from North Carolina to Florida, from the shoreline to 250 NM seaward	50,000 NM ² of sea and undersea space. Includes three OPAREAs: Charleston, Jacksonville and Cape Canaveral Includes the Undersea Warfare Training Range	64,000 NM ² of special use airspace
Naval Surface Warfare Center, Carderock Division, South Florida Ocean Measurement Facility Testing Range (SFOMF)	Located adjacent to the Port Everglades entrance channel in Fort Lauderdale, Florida; out to 25 NM from shore	500 NM ² of sea and undersea space	No associated special use airspace
Key West Range Complex (KWRC)	Off the southwestern coast of mainland Florida and along the southern Florida Keys, extending into the Gulf of America and the Straits of Florida	8,000 NM ² of sea and undersea space south of Key West. Includes one OPAREA: Key West	23,000 NM ² of special use airspace
Naval Surface Warfare Center, Panama City Testing Range	Off the panhandle of Florida and Alabama, extending from the shoreline 120 NM seaward and includes St. Andrew Bay	23,000 NM ² of sea and undersea space Includes two OPAREAs: Panama City and Pensacola	23,000 NM ² of special use airspace
Gulf Range Complex	Includes geographically separated areas throughout the Gulf of America	20,000 NM ² of sea and undersea space Includes four OPAREAs: Panama City, Pensacola, New Orleans, and Corpus Christi	43,000 NM ² of special use airspace

Table 39. Inshore Waters Included in the AFTT Action Area

<i>Name</i>	<i>Associated Inshore Waters</i>
Northeast Range Complexes Inshore	Thames River Narragansett Bay Rhode Island Sound Block Island Sound
VACAPES Range Complex Inshore	Lower Chesapeake Bay James River and tributaries Broad Bay York River
JAX Range Complex Inshore	Blount’s Island Southeast Kings Bay Cooper River St. Johns River Port Canaveral
Key West Range Complex Inshore	Truman Harbor Demolition Key
Gulf Range Complex Inshore	St. Andrew Bay Mobile Bay Atchafalaya Bay Atchafalaya River Lake Borgne Pascagoula River

4 SPECIES AND DESIGNATED CRITICAL HABITAT THAT MAY BE AFFECTED

ESA implementing regulations for section 7(a)(2) allow for three general determinations for listed species and critical habitat: 1) no effect, 2) may affect, not likely to adversely affect (NLAA), and 3) may affect, likely to adversely affect (LAA). Action agencies, prior to requesting ESA consultation, determine whether their proposed action may affect ESA-listed species or their designated or proposed critical habitat. Generally, a “no effect” determination means there is no plausible route of effects between the proposed action and any ESA-listed species or designated or proposed critical habitat and does not require consultation. Any scenario where there is a plausible route of effects is considered “may affect.” For any action that “may affect” an ESA-listed species or its designated critical habitat, the action agency shall consult with the Services under section 7(a)(2) of the ESA.

An action agency is also required to confer with the Services on any effects to proposed species or proposed critical habitat if those effects are likely to jeopardize the continued existence of the species or destroy or adversely modify the proposed critical habitat. However, action agencies may voluntarily confer with the Services for all proposed species or proposed critical habitat in the action area when the action may affect those proposed entities without rising to a level requiring us to confer.

This section of the opinion considers: 1) the stressors generated by the proposed action (Section 2.4), and 2) the action area (Section 3) to identify the ESA-listed species and designated or

proposed critical habitat that may be affected by those stressors in the action area. These ESA-listed species and designated or proposed critical habitats that may be affected by this action, along with their regulatory status, are shown in Table 40.

Table 40. ESA-listed Species and Designated or Proposed Critical Habitat that May Be Affected by the Proposed Action with Listing Status and Recovery Plan Information

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (<i>Balaenoptera musculus</i>)	E – 35 FR 18319	-- --	07/1998 11/2020
Fin Whale (<i>Balaenoptera physalus</i>)	E – 35 FR 18319	-- --	07/2010
Rice’s Whale (<i>Balaenoptera ricei</i>)	E – 84 FR 15446 and 86 FR 47022	88 FR 47453 (Proposed)	09/2020 (Outline)
North Atlantic Right Whale (<i>Eubalaena glacialis</i>)	E – 73 FR 12024	81 FR 4837	08/2004
Sei Whale (<i>Balaenoptera borealis</i>)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (<i>Physeter macrocephalus</i>)	E – 35 FR 18319	-- --	12/2010
Sea Turtles			
Green Turtle (<i>Chelonia mydas</i>) – North Atlantic DPS	T – 81 FR 20057	88 FR 46572 (Proposed)	10/1991
Hawksbill Turtle (<i>Eretmochelys imbricata</i>)	E – 35 FR 8491	63 FR 46693*	10/1993
Kemp’s Ridley Turtle (<i>Lepidochelys kempii</i>)	E – 35 FR 18319	-- --	09/2011
Leatherback Turtle (<i>Dermochelys coriacea</i>)	E – 35 FR 8491	44 FR 17710*	10/1991
Loggerhead Turtle (<i>Caretta caretta</i>) – Northwest Atlantic Ocean DPS	T – 76 FR 58868	79 FR 39855	12/2008
Fishes			
Atlantic Salmon (<i>Salmo salar</i>) – Gulf of Maine DPS	E – 65 FR 69459 and 74 FR 29344	74 FR 39903*	2/2019 (Final)
Atlantic Sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>) – Carolina DPS	E – 77 FR 5913	82 FR 39160	03/2018 (Outline)
Atlantic Sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>) – Chesapeake DPS	E – 77 FR 5879	82 FR 39160	03/2018 (Outline)
Atlantic Sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>) – Gulf of Maine DPS	T – 77 FR 5879	82 FR 39160*	03/2018 (Outline)
Atlantic Sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>) – New York Bight DPS	E – 77 FR 5879	82 FR 39160	03/2018 (Outline)

Species	ESA Status	Critical Habitat	Recovery Plan
Atlantic Sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>) – South Atlantic DPS	E – 77 FR 5913	82 FR 39160	03/2018 (Outline)
Giant Manta Ray (<i>Manta birostris</i>)	T – 83 FR 2916	-- --	12/2019 (Outline)
Gulf Sturgeon (<i>Acipenser oxyrinchus desotoi</i>)	T – 56 FR 49653	68 FR 13369	09/1995
Nassau Grouper (<i>Epinephelus striatus</i>)	T – 81 FR 42268	89 FR 126	8/2018 (Outline)
Oceanic Whitetip Shark (<i>Carcharhinus longimanus</i>)	T – 83 FR 4153	-- --	9/2018 (Outline)
Scalloped Hammerhead Shark (<i>Sphyrna lewini</i>) – Central and Southwest Atlantic DPS	T – 79 FR 38213	-- --	-- --
Shortnose Sturgeon (<i>Acipenser brevirostrum</i>)	E – 32 FR 4001	-- --	12/1998
Smalltooth Sawfish (<i>Pristis pectinata</i>) – U.S. portion of range DPS	E – 68 FR 15674	74 FR 45353*	01/2009
Marine Invertebrates			
Boulder Star Coral (<i>Orbicella franksi</i>)	T – 79 FR 53851	88 FR 54026	-- --
Elkhorn Coral (<i>Acropora palmata</i>)	T – 79 FR 53851	73 FR 72210	80 FR 12146
Lobed Star Coral (<i>Orbicella annularis</i>)	T – 79 FR 53851	88 FR 54026	-- --
Mountainous Star Coral (<i>Orbicella faveolata</i>)	T – 79 FR 53851	88 FR 54026	-- --
Pillar Coral (<i>Dendrogyra cylindrus</i>)	E – 89 FR 101993	88 FR 54026	-- --
Rough Cactus Coral (<i>Mycetophyllia ferox</i>)	T – 79 FR 53851	88 FR 54026	-- --
Queen conch (<i>Aliger gigas</i>)	T – 89 FR 11208	-- --	-- --
Staghorn Coral (<i>Acropora cervicornis</i>)	T – 79 FR 53851	73 FR 72210	80 FR 12146

* Indicates that designated critical habitat does not overlap with the action area or any stressors resulting from the proposed action.

4.1 May Affect, Not Likely to be Adversely Affected

Once we have determined the action may affect ESA-listed species and designated or proposed critical habitat, the next step is differentiating between stressors that are NLAA and LAA for each listed species and critical habitat in the action area. An action warrants a NLAA finding when its effects are completely beneficial, discountable, or insignificant. Completely beneficial effects have an immediate positive effect without any adverse effects to the species or habitat. Completely beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected, albeit positively. Discountable effects are those that could occur while an ESA-listed

species is in the action area but, because of the intensity, magnitude, frequency, duration, or timing of the stressor, exposure to the stressor is extremely unlikely to occur. Insignificant effects relate to the response of exposed individuals where the response, in terms of an individual's growth, survival, or reproduction, would be immeasurable or undetectable, or an impact to the conservation value of a PBF of critical habitat would be immeasurable or undetectable. For stressors that meet these criteria for either completely beneficial, discountable, or insignificant, the appropriate conclusion is NLAA.

To assist us in reaching a determination, we perform a two-step assessment that considers all of the stressors identified in Section 2.4 of this opinion and all of the species and critical habitats within the action area (see Table 40) to understand the likelihood of the stressors having an effect on the ESA-listed species or their critical habitat. First, we consider whether it is likely that a listed species or critical habitat is exposed to a stressor or there is a reasonable expectation of the stressor and an individual or habitat co-occurring. If we conclude that exposure of a species or critical habitat to a stressor caused by the proposed action or activity is discountable, we must also conclude it is NLAA. However, if exposure is probable, the second step is to evaluate the probability of a response to the stressor. When all stressors of an action are found to be NLAA for a listed species or a critical habitat, we conclude informal consultation for that species or critical habitat. Likewise, if a stressor associated with an action is found to be NLAA for all listed species and all critical habitats, there is no need to continue analyzing the consequences of that stressor in our Analysis of Effects (Section 6). Where the negative effects to any species or critical habitat or from any stressor to those species or critical habitat are found to exceed the standards of insignificant or discountable, we must analyze those consequences in our Analysis of Effects.

4.1.1 Stressors Not Likely to Adversely Affect ESA-listed Species

In our 2018 AFTT Phase III biological opinion (NMFS 2018a) Analysis of Effects section we determined that some stressors associated with the action were not likely to adversely affect any ESA-listed species because any effects of that stressor would be either insignificant or discountable. Based on a review of newly available information (since completion of the 2018 opinion), we found no new information that would change our NLAA determination for any of these stressors. That is, there is no new information that reveals effects of the proposed action that may affect ESA-listed species in the action area in a manner or to an extent not previously considered for these NLAA stressors. Although changes have been made to the proposed action (i.e., from Phase III to Phase IV), we have determined that, for the NLAA stressors discussed below, the action has not been modified in a manner that causes an effect to ESA-listed species that was not previously considered in the 2018 biological opinion, and we reaffirm our 2018 NLAA determinations for these stressors.

In the sections below, we summarize our findings regarding the likelihood of exposure, and how ESA-listed species and habitats are expected to respond, if exposed to these stressors. Any new (i.e., since the 2018 opinion) and relevant information for our analysis is discussed here, and we

refer the reader to Section 9.1 (pp. 363-446) of the 2018 AFTT Phase III biological opinion (NMFS 2018a) for a more detailed discussion. Where appropriate, we also incorporate, by reference, sections of the Action Proponents AFTT Phase IV BA (Navy 2024c) into this biological opinion.

Our analyses of the effects of NLAA stressors to species is organized by species group (i.e., marine mammals, sea turtles, fish, invertebrates) because, in general, we expect species within each group to respond in similar ways to these stressors. Where different responses by a species or subgroup (e.g., mysticetes versus odontocetes) within a species group have been documented in the literature, we consider those differences in our analysis. We then summarize our findings for each species group, and provide the rationale for our determination that the identified NLAA stressors resulting from the proposed action are not likely to adversely affect any of the ESA-listed species within each species group. For some stressors, we determined there is no pathway to effects (i.e., no effect) to certain species (or species groups) and, therefore, no need to analyze those stressors in relation to those species.

Our analyses of the effects of NLAA stressors on designated and proposed critical habitat is provided in Section 4.1.3. For many NLAA stressors, we determined that there is no pathway to effects (i.e., no effect) to the PBFs of critical habitat and, therefore, no need to analyze those stressors here.

Acoustic Stressors

Vessel Noise

Action Proponent vessel movements involve transits to and from ports to various locations within the action area, and many proposed activities within the action area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels), as well as unmanned vehicles. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to two weeks.

The ESA-listed marine mammals, sea turtles, and fish considered in this opinion will be exposed to noise from Action Proponent vessels during training and testing activities in the action area. Vessel source sound levels are below those that would cause hearing loss or auditory injury in ESA-listed species. Therefore, the focus of our vessel noise analysis is on the behavioral, physiological and potential masking effects of this stressor. Behavioral and physiological responses to vessels can be caused by multiple factors. It is difficult for researchers and analysts to separate the effects of vessel noise and vessel presence; therefore, this analysis will consider both aspects. Additional discussion on vessel noise as a potential stressor is included in Section 2.4.1.

Marine Mammals

Mysticetes (baleen whales) demonstrate a variety of responses to vessel traffic and noise, from not responding at all to both horizontal (swimming away) and vertical (increased diving)

avoidance (Baker et al. 1983; Reeves et al. 1998; Nowacek et al. 2004; Gende et al. 2011). Other common responses include changes in vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Williams et al. 2002; Richter et al. 2003). The likelihood of response may be driven by the distance or speed of the vessel, the animal's behavioral state, or by the prior experience of the individual or population (Leatherwood et al. 1982; Bernasconi et al. 2012).

Mysticetes have been shown to both increase (Doyle et al. 2008; Melcon et al. 2012) and decrease (Sousa-Lima and Clark 2008; Castellote et al. 2012; Dearden 2025) calling behavior in the presence of vessel noise depending on the context (i.e., types/purpose of calls produced and type of activity engaged in). Changes in the amplitude or frequency of vocalizations in the presence of increased vessel noise have also been observed (Parks et al. 2007a; Parks 2011). The long-term consequences of vessel noise are not well understood. Some studies suggest that short-term responses may not lead to long-term consequences, and that over time animals may habituate to the presence of vessel traffic (Watkins 1986).

Overall baleen whale responses to vessel noise and traffic are varied but are generally minor, and habituation or disinterest seems to be the predominant long-term response. If baleen whales do avoid ships, they do so by altering their swim and dive patterns to move away from the vessel, but no strong reactions have been observed. In many cases, whales do not appear to change their behavior at all. This may result from habituation by the whales, but may also result from reduced received levels near the surface due to propagation, or due to acoustic shadowing of the propeller cavitation noise by the ship's hull.

Most odontocetes react neutrally to vessels, although both avoidance and attraction behavior have been observed (Hewitt 1985; Wursig et al. 1998; Bejder et al. 2006). Sperm whales, the only ESA-listed odontocetes in the action area, generally react only to vessels approaching within several hundred meters. However, some individuals may display avoidance behavior, such as quick diving (Wursig et al. 1998; Magalhaes et al. 2002) or a decrease in time spent at the surface (Isojunno and Miller 2015). One study showed that after diving, sperm whales showed a reduced time frame before they emitted the first click than prior to a vessel interaction (Richter et al. 2006). Azzara et al. (2013) also found a reduction in sperm whale clicks while a vessel was passing, as well as up to a half hour after the vessel had passed.

The ESA-listed marine mammals considered in this opinion may also experience masking due to vessel noises. Vessel noise can potentially mask vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely on. Potential masking can vary depending on the ambient noise level within the environment, the received level and frequency of the vessel noise, and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 μ Pa in the band between 10 Hz and 10 kHz due to a combination of natural (e.g., wind) and anthropogenic sources (Urick 1983), while inshore noise levels, especially around busy ports, can exceed 120 dB re 1 μ Pa. When the noise level is above the sound of interest, and in a similar frequency

band, masking could occur. This analysis assumes that any sound that is above ambient noise levels and within an animal's hearing range may potentially cause masking. However, the degree of masking increases with increasing noise levels; a noise that is just detectable over ambient levels is unlikely to cause any substantial masking.

Right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007a) as well as increasing the amplitude (intensity) of their calls (Parks et al. 2009; Parks et al. 2011a). Right whales also had their communication space reduced by up to 84% in the presence of vessels (Clark et al. 2009a). Although humpback whales did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected, potentially indicating some signal masking (Dunlop 2016).

The ESA-listed marine mammals considered in this opinion will be exposed to noise from Action Proponent vessels during training and testing activities in the action area. As documented above, vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. These reactions are anticipated to be short-term, likely lasting the amount of time the vessel and the whale are in close proximity (e.g., Watkins 1981; Richardson et al. 1995b; Magalhaes et al. 2002), and not consequential to the animals. Additionally, the effects of any temporary masking specifically from Navy and Coast Guard vessels are expected to be of a short duration and not result in meaningful changes to an animal's ability to communicate or detect biologically relevant cues given: 1) the intermittent and sporadic nature of Action Proponent vessel activity, 2) the fact that the sound (i.e. vessel) and the receiver (whale) are both moving continuously and likely in different directions, 3) the background noise levels in the action area independent of military vessels, and 4) the small percentage of vessel traffic Action Proponent vessels represent in the action area (as discussed in Section 2.4.1).

In summary, ESA-listed marine mammals are either not likely to respond to vessel noise and disturbance or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Therefore, the effects of vessel noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Additionally, the effects of any temporary masking specifically from Action Proponent vessels is insignificant given the background noise levels in the action area independent of these vessels, and the small percentage of vessel traffic these vessels represent in the action area. Thus, we conclude that the effects of vessel noise and disturbance resulting from the proposed action may affect, but are not likely to adversely affect the following marine mammal species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

For a more detailed discussion of marine mammal responses to vessel noise and disturbance, we refer the reader to portions of the Action Proponents AFTT BA (Section 4.4.2.1.1.5, pp 4-449 to 4-452 and 4-457 to 4-460), which we incorporate here by reference (Navy 2024c).

Sea Turtles

Action Proponent vessels used during training and testing activities will produce low-frequency, broadband underwater sound below 1 kHz (for larger vessels), and higher-frequency sound between 1 kHz to 50 kHz (for smaller vessels), although the exact level of sound produced varies by vessel type. ESA-listed turtles could be exposed to a range of vessel noises within their hearing abilities. Depending on the context of exposure, potential responses of North Atlantic DPS green, hawksbill, Kemp's ridley, leatherback, and the Northwest Atlantic DPS of loggerhead sea turtles to vessel noise and disturbance, would include startle responses, avoidance, or other behavioral reactions, and physiological stress responses.

Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggested that turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise. Díaz et al. (2024) found that green sea turtles travelling in the Galapagos Archipelago increased their vigilance with increasing vessel noise.

Based on the available information, vessel noise is expected to cause minimal behavioral disturbance to sea turtles. If a sea turtle detects a vessel and avoids it or has a stress response from the noise disturbance, these responses are expected to be temporary and only endure while the vessel transits through the area where the sea turtle encountered it. Therefore, sea turtle responses to vessel noise disturbance are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated), and a sea turtle would be expected to return to normal behaviors and stress levels shortly after the vessel passes by. Thus, we conclude that the effects of vessel noise and disturbance resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, leatherback, and Northwest Atlantic DPS loggerhead sea turtles.

Fish

All fish species have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Popper and Schilt 2009). The lateral line system, a specialized sensory organ in fish, allows them to detect subtle water motions and pressure gradients. ESA-listed fish considered in this opinion may be exposed to sound from vessel movement during Action Proponent training and testing activities. In general, information

regarding the effects of vessel noise on fish hearing and behaviors is limited. Temporary threshold shift (TTS) has been observed in fish exposed to elevated background noise and other white noise, a continuous sound source similar to the noise produced from vessels. Caged studies on sound pressure sensitive fish show some TTS after several days or weeks of exposure to increased background sounds, although the hearing loss appeared to recover (e.g., Scholik and Yan 2002; Smith et al. 2004; Smith et al. 2006). Smith et al. (2004) and Smith et al. (2006) exposed goldfish (a fish with hearing specializations, unlike any of the ESA-listed species considered in this opinion) to noise with a sound pressure level (SPL) of 170 dB re 1 μ Pa and found a clear relationship between the amount of TTS and duration of exposure, until maximum hearing loss occurred at about 24 hours of exposure. A short duration (e.g., 10-minute) exposure resulted in 5 dB of TTS, whereas a three-week exposure resulted in a 28 dB TTS that took over two weeks to return to pre-exposure baseline levels (Smith et al. 2004). Recovery times were not measured by researchers for shorter exposure durations, so recovery time for lower levels of TTS was not documented.

Vessel noise may also affect fish behavior by causing them to startle, swim away from an occupied area, change swimming direction and speed, or alter schooling behavior (Engas et al. 1995; Engas et al. 1998; Mitson and Knudsen 2003). Physiological responses have also been documented for fish exposed to increased boat noise. Nichols et al. (2015) demonstrated physiological effects of increased noise (playback of boat noise) on coastal giant kelpfish. The fish exhibited acute stress responses when exposed to intermittent noise, but not to continuous noise. These results indicate variability in the acoustic environment may be more important than the period of noise exposure for inducing stress in fish. Other studies have also shown exposure to continuous or chronic vessel noise may elicit stress responses indicated by increased cortisol levels (Scholik and Yan 2001; Wysocki et al. 2006). These experiments demonstrate physiological and behavioral responses to various boat noises that could affect species' fitness and survival but may also be influenced by the context and duration of exposure. It is important to note that most of these exposures were continuous, not intermittent, and the fish were unable to avoid the sound source for the duration of the experiment because these were controlled studies. In contrast, wild fish such as those considered in this opinion are not hindered from movement away from an irritating sound source, if detected, so are less likely to be subjected to accumulation periods that lead to the onset of hearing damage as indicated in these studies. In other cases, fish may eventually become habituated to the changes in their soundscape and adjust to the ambient and background noises.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Action Proponent vessels produce moderate to low-level passive sound sources (larger ships would produce low-frequency, broadband underwater sound below one kHz; and smaller vessels emit higher-frequency sound between 1 kHz to 50 kHz). Therefore, ESA-listed fish could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from Action Proponent

vessels is unlikely to result in direct injury, hearing impairment, or other trauma to fish. Plus, in the near field, fish are able to detect water motion as well as visually locate an oncoming vessel. In these cases, most fish located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors. Auditory masking due to vessel noise can potentially mask vocalizations and other biologically important sounds that fish may rely on. However, impacts from Navy and Coast Guard vessel noise would be intermittent, temporary and localized, and such responses would not be expected to compromise the general health or condition of individual fish from continuous exposures. Instead, the only impacts expected from exposure to Action Proponent vessel noise for fish may include temporary auditory masking, physiological stress, or minor changes in behavior.

As discussed above, exposure to vessel noise for fish could result in short-term behavioral or physiological responses (e.g., avoidance, stress). Vessel noise would only result in brief periods of exposure for fish and would not be expected to accumulate to the levels that would lead to any injury, hearing impairment or long-term masking of biologically relevant cues. For these reasons, exposure to vessel noise is not expected to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Therefore, we conclude that the effects of vessel noise exposure from the proposed action may affect but are not likely to adversely affect the following ESA-listed fish species: Nassau grouper, shortnose sturgeon, Atlantic sturgeon, Atlantic salmon, scalloped hammerhead sharks, giant manta rays, smalltooth sawfish, and oceanic whitetip sharks.

Invertebrates

Most marine invertebrates, including corals and mollusks, possess specialized mechanisms for detecting acoustic stimuli that differ fundamentally from those of vertebrates. Rather than responding primarily to sound pressure, invertebrates are mainly sensitive to particle motion, particularly when they live close to the seabed where substrate vibration plays a significant role (Solé et al. 2023). This detection occurs through various specialized organs, including ciliated hair cells and statocysts, which allow these organisms to sense local water movements and maintain equilibrium (Solé et al. 2023). The detection range is typically limited, as particle motion diminishes rapidly with distance from the sound source, making the impact of noise highly dependent on proximity to its source. The detection range is typically limited since particle motion diminishes rapidly with distance from the sound source. This understanding is crucial for evaluating potential impacts of military training and testing activities.

Different invertebrate species exhibit distinct behavioral modifications when exposed to anthropogenic noise (Davies et al. 2024). Recent research has documented varied responses across different taxonomic groups. For instance, razor clams respond to white noise and sine waves by initiating defensive digging behavior at sound levels around 100 dB re 1 μ Pa, while

showing no response at lower levels (Charifi et al. 2018). In contrast, Mediterranean mussels exposed to acoustic sweeps demonstrated no significant behavioral changes, even at relatively high sound pressure levels. These divergent responses highlight the species-specific nature of behavioral adaptations to acoustic disturbance.

Some adults of ESA-listed corals and queen conch could potentially detect the low-frequency component of nearby vessel noise, although there are no studies of the effects of vessel noise on adult marine invertebrates. Coral larvae exposed to vessel noise near a reef could experience temporary masking and brief disruption of settlement cues (Pysanczyn et al. 2023). However, potential interference in the ability of coral larvae to detect reef sounds would be temporary, lasting only the duration that the vessel is in the immediate vicinity of the larval coral. Since Action Proponent vessels are generally transiting during training and testing, exposures and potential masking would be brief. Military sonar activities typically occur seaward of the coastal zone, maintaining distance from most ESA-listed coral habitats. When operations do occur near coral habitats, the exposure would need to be extremely close to cause particle motion sufficient to trigger a response. Such close proximity would represent a navigation hazard and is therefore actively avoided through standard operating procedures. This spatial separation provides an additional layer of protection for coral populations beyond their inherent limited sensitivity to acoustic signals.

In summary, we do not expect these brief interruptions to inhibit the ability of coral larvae to detect reef habitat. Therefore, the likely effects from exposure to vessel noise on ESA-listed corals are considered insignificant, and thus are not likely to cause adverse effects. We have little information on the effects of vessel noise on queen conch but would assume similar effects as to other marine invertebrate species. Queen conch may be able to detect vibrations of water particles caused by moving vessels but will either not respond or their response would be insignificant. Therefore, we conclude that the effects of vessel noise exposure from the proposed action may affect but are not likely to adversely affect ESA-listed corals or queen conch.

Aircraft Overflight Noise and Disturbance

Aircraft overflights will usually occur near Navy airfields, installations, and in special use airspace within Navy Range Complexes. Aircraft flights during training would be most concentrated within the Virginia Capes, Navy Cherry Point, JAX and Key West Range Complexes. Additional discussion of aircraft overflight noise as a potential stressor is included in Section 2.4.1.

Marine Mammals

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

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft and helicopters, as well as unmanned aerial vehicles. Thorough reviews of the subject and available information is presented elsewhere (e.g., Efroymson et al. 2001; Luksenburg and Parsons 2009; Holst et al. 2011; Smith et al. 2016). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping; Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Manci et al. 1988; Holst et al. 2011).

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998). Richardson et al. (1985) and Richardson et al. (1995b) found no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals.

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft (304.8 m) above sea level, infrequently observed at 1,500 ft (457.2 m), and not observed at all at 2,000 ft (609.6 m) (Richardson et al. 1985). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 150 m or higher. The bowheads exhibited fewer behavioral changes than did the odontocetes in the same area (Patenaude et al. 2002).

During standard marine mammal surveys at an altitude of 750 ft, some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Wursig et al. 1998; Richter et al. 2003; Richter et al. 2006; Smultea et al. 2008). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors. A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Whale-watching aircraft (fixed-wing airplanes and helicopters) apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003).

The average of the underwater received levels detected by Kuehne et al. (2020) produced by Growler aircraft (EA-18G) in the strongest 1-second window was 134 ± 3 dB re $1 \mu\text{Pa}$ at 30 m below the sea surface. However, since these take-off levels would occur for a small amount of time (seconds), it is extremely unlikely that ESA-listed marine mammals would co-occur in time and space with aircraft sound at levels that could result in adverse effects. Any exposures of cetaceans to aircraft noise that may occur this close to the surface would likely be short-term and infrequent, resulting in either no measurable response or a brief, inconsequential behavioral response.

To summarize, in most cases, exposure of a marine mammal to fixed-wing aircraft presence and noise resulting from the proposed action would last for only seconds as the aircraft quickly passes overhead, typically at altitudes above 3,000 ft, which would make marine mammals unlikely to respond. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields as well as on vessels at sea at unspecified locations across the action area. Takeoffs and landings from vessels could startle marine mammals. However, these events only produce in-water noise at any given location for a brief period as the aircraft climbs to cruising altitude. Some sonic booms from aircraft could startle marine mammals, but these events are transient and happen infrequently at any given location within the action area. Due to the short term and infrequent nature of any exposures to fixed-wing aircraft, and the brief responses that would likely follow such exposure, the effects of fixed-wing aircraft overflight on ESA-listed marine mammals is insignificant.

Low flight altitudes of helicopters during some anti-submarine warfare and mine warfare activities, often under 100 ft, may elicit a somewhat stronger behavioral response due to the proximity to marine mammals, the slower airspeed and therefore longer exposure duration, and the downdraft created by the helicopter's rotor. Marine mammals would likely avoid the area under the helicopter due to the downdraft, noise, and presence of the helicopter. It is unlikely that an individual would be exposed repeatedly for long periods because these aircraft typically transit open ocean areas within the action area. The literature cited above indicates that aircraft noise would cause only small temporary changes in the behavior of marine mammals. Specifically, marine mammals at or near the surface when a helicopter flies overhead at low altitude may startle, divert their attention to the aircraft, or avoid the immediate area by swimming away or diving.

In summary, due to the short-term nature of any exposures to aircraft and the brief responses that could follow such exposure, the effects of aircraft overflight noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effects cannot be meaningfully evaluated). Thus, we conclude that the effects of aircraft overflight noise and disturbance resulting from the proposed action may affect, but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

Sea Turtles

Like vessel disturbance as described above, little information is available on how ESA-listed sea turtles respond to aircraft. For the purposes of this consultation, we assume all ESA-listed sea turtles (North Atlantic DPS of green, hawksbill, Kemp's ridley, Northwest Atlantic DPS of loggerhead, and leatherbacks) may exhibit similar short-term behavioral responses such as diving, changes in swimming, etc., which is also consistent with those behaviors observed during aerial research surveys of sea turtles. While we are unaware of any data on the physiological responses sea turtles exhibit to aircraft, we assume that a low-level, short-term stress response is possible.

The working group that developed the 2014 *American National Standards Institute (ANSI) Guidelines* for fishes and sea turtles did not consider this specific acoustic stressor for sea turtles, in part because it is not considered to pose a great risk (Popper et al. 2014). Although the aircraft used by the Action Proponents can produce extensive airborne noise from either turbofan or turbojet engines, via sonic booms, and from rotary wing low-frequency sound and vibration, depending on the altitude, some sound would not be transmitted into the water, and any low-flying altitude air craft would only likely transmit low levels of sound within 1 m into the water column. As mentioned previously, we assume that sea turtles located at or near the water surface may exhibit startle reactions to certain aircraft overflights if the aircraft is flying at a low altitude and the turtle can see it or detect it through sound or water motion generated from wind currents on the surface. This would most likely occur when helicopters are hovering (other aircraft are mostly flying at higher altitudes) and might be visually detected by a sea turtle. The currents and waves the helicopter produces on the water's surface may also cause sea turtles to respond to the disturbance along with the sound. Longer duration activities (such as a couple of hours) involving periods of time where helicopters hover may increase the chance that a sea turtle will startle, change swimming patterns, or have a physiological stress response. There could also be temporary masking of biologically relevant cues from exercises that generate longer duration of sound exposure with a hovering helicopter. However, in general, aircraft overflight is brief, and does not persist in the action area for significant periods of time (not longer than a few hours), nor is the sound expected to be transmitted well into the water column. Thus, the risk of masking any biologically relevant sound to sea turtles is extremely low. A sea turtle could leave the area where noise disturbance persists for a few hours, and thereby avoid continued disturbance. Any startle reactions that occur are expected to be brief, with sea turtles resuming normal behaviors once the aircraft is no longer detectable or leaves the area. Due to the short-term nature of any exposures to aircraft and the brief responses expected to the noise or visual disturbance produced, the effects of aircraft overflight noise on ESA-listed sea turtles is considered temporary and insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of aircraft overflight noise and disturbance resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, leatherback, and Northwest Atlantic DPS loggerhead sea turtles.

Fish

Direct injury and hearing impairment in fishes is unlikely to occur from aircraft overflight noise, because sounds from aircraft noise, including occasional sonic booms, lack the amplitude or duration to cause any physical damage to fishes underwater. Furthermore, due to the brief and dispersed nature of aircraft overflights, masking of biologically relevant sounds for fishes is also extremely unlikely. In the rare circumstance a fish detects sound produced from an aircraft overhead, only very brief startle or avoidance responses would be expected. Acoustic energy in the air does not effectively cross the air-water interface and noise can be reflected off the water surface (Richardson et al. 1995a). Research conducted by the U. S. Air Force (Air Force)

reported significant reductions in noise underwater related to in-air sonic booms, indicating a lack of harassment risk for protected marine species under water (USAF 2000). Sound waves in air can be reduced by a factor of more than a thousand when they cross the air-sea interface (Hildebrand 2005), constituting a substantial sound barrier. While aircraft overflight noise exposure may cause short-term physiological stress or behavioral reactions, these effects are considered insignificant and, thus, may affect but are not likely to adversely affect the following ESA-listed fish species: Nassau grouper, shortnose sturgeon, Atlantic sturgeon, Atlantic salmon, scalloped hammerhead sharks, giant manta rays, smalltooth sawfish, and oceanic whitetip sharks.

Noise from Weapons

The use of weapons during proposed activities would generally occur in the range complexes, with greatest use of most types of munitions in the VACAPES and JAX Range Complexes (Navy 2024c). 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 (Navy 2024c). All of the noise produced during the use of the weapons described here is expected to be brief (a few seconds). Most incidents of impulsive sounds produced by weapons firing, launch, or inert object impacts would be single events, with the exception of gunfire activities. Gunfire activities could produce multiple shots fired over a brief period of time. The Action Proponents will implement mitigation to avoid or reduce potential impacts from weapon firing noise during large-caliber gunnery activities, as discussed in Section 2.3.2. Additional discussion of weapons noise as a potential stressor is included in Section 2.4.1.

Marine Mammals

Marine mammals may be exposed to sounds caused by the firing of weapons, objects in flight, and inert impact of non-explosive munitions on the water's surface. A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle into the water. Most in-air sound would be reflected at the air-water interface (Navy 2024c). Underwater sounds would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile (Navy 2024c). Yagla and Stiegler (2003) found that the average peak sound pressure in the water measured directly below the muzzle of the gun and under the flight path of the shell (assuming it maintains an altitude of only a few meters above the water's surface) was approximately 200 dB re 1 μ Pa.

Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. These sounds would be transient and of short duration, lasting no more than a few seconds at any given location. Many missiles are launched from aircraft, which would produce minimal noise in the water due to the altitude of the aircraft at launch. Missiles and targets launched by ships or near the water's surface may expose marine mammals to levels of sound that could produce brief startle reactions, avoidance, or diving. Some objects, such as hyperkinetic projectiles and non-explosive practice munitions, could impact the water with great force and produce a relatively large

impulse.⁹ Animals within the area may hear the impact of non-explosive ordnance on the surface of the water and would likely alert, startle, dive, or avoid the immediate area.

Marine mammals at the surface of the water, in the narrow footprint under a weapons trajectory, could be exposed to gunfire noise and may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Behavioral reactions would likely be short-term (second to minutes) and due to the short-duration, transient nature of launch noise, animals are unlikely to be exposed multiple times within a short period. Masking of biologically relevant sounds is also not expected to occur because weapons noise will not persist for a long enough duration.

For the reasons above, the effects of weapon noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of noise from weapons firing resulting from the proposed action may affect, but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

Sea Turtles

Individual sea turtles from all of the ESA-listed species (North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles) considered in this opinion may be exposed to sounds caused by the weapons firing (guns, missile, torpedoes), objects dropping in the water, and inert impact of non-explosive munitions on the water's surface. Given that these sounds are below injury criteria for sea turtles (discussed in Section 6.2.1), and are expected to be very brief and intermittent over the duration of activities in the action area, only brief startle reactions, diving responses or other avoidance behaviors are likely to occur for sea turtles. Masking of biologically relevant sounds is also not expected to occur because weapons noise will not persist for a long enough duration. Most activities producing weapons noise will typically occur more than 12 NM from the coast; therefore, sea turtles would still be able to detect biologically relevant sounds near the coastal areas they inhabit or need to detect near nesting beaches.

In addition, as described in the mitigation measures (Section 2.3.2) for the proposed action, the Navy will not commence with weapons firing if *Sargassum* mats are observed, or if a sea turtle is observed within the mitigation zone. These measures will help reduce the likelihood of impacts on hatchling and pre-recruitment juveniles of all sea turtle species and leatherback turtles of all age classes because these species and age classes are known to congregate around *Sargassum*. For these reasons, any physiological stress and behavioral reactions from weapons firing noise would likely be brief and are expected to return to normal shortly after the weapons noise ceases. Therefore, the effects on sea turtles from weapons noise exposure are anticipated to be minor, temporary and will not lead to a significant disruption of normal behavioral patterns. As such the effects from weapons noise on sea turtles is considered insignificant (i.e., so minor that the effect

⁹ Note that the potential for objects to physically strike an ESA-listed marine mammal is discussed in section 9.1.1.4.

cannot be meaningfully evaluated). Thus, we conclude that the effects of noise from weapons firing resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles.

Fish

Of the ESA-listed fishes likely to be present during the firing of weapons during Navy training and testing activities, Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, oceanic whitetip sharks, and Central and Southwest DPS of scalloped hammerhead sharks, could all be exposed to noise from weapons firing, launch, flight downrange, and from the impact of non-explosive munitions. Nassau grouper, shortnose sturgeon and smalltooth sawfish are not expected to encounter weapons noise. Nassau grouper are typically located along the seafloor and near reef systems outside the range of these activities. Shortnose sturgeon will not encounter weapons noise due to a lack in habitat overlap (i.e., they are largely confined to rivers and estuaries) within the action area where AFTT activities will not occur. In addition, smalltooth sawfish are typically found in nearshore, shallow waters (less than 1 m) around the tip of Florida where no weapons noise is expected. Although a few adults could be located in deep water reefs around Florida, they are not expected to encounter weapons noise since the majority of the sound would occur at the water's surface. Therefore, since exposure to weapons noise is extremely unlikely (i.e., discountable) for these species, we conclude that weapons noise may affect but is not likely to adversely affect Nassau grouper, shortnose sturgeon or smalltooth sawfish.

For the other ESA-listed fish species in the action area, weapons noise could affect fishes located at the surface of the water, albeit in a narrow footprint under a weapons trajectory, as described previously. In addition, any objects that are dropped and impact the water with great force could produce a loud broadband sound at the water's surface from large-caliber non-explosive projectiles, non-explosive bombs, and intact missiles and targets (McLennan 1997).

Naval gunfire could also elicit a brief behavioral reaction such as startle reactions or avoidance and could expose fishes to multiple shots within a few seconds. The sound produced from missile and target launches is typically at a maximum during initiation of the booster rocket, but rapidly fades as the missile or target travels downrange; therefore this noise is unlikely to affect fishes underwater. These are launched from aircraft which would produce minimal sound in the water due to the altitude of the aircraft when these are fired.

For exposed fishes, most of the weapons noise produced from these activities lack sound characteristics such as duration and high intensity that would accumulate or cause mortality, injury, or hearing impairment. The average peak levels of 200 dB are also below the peak levels for impulsive sound sources that could lead to onset of injury for fishes (see Section 6.3.1 below for details). Additionally, because these activities are brief in duration and widely dispersed throughout the action area, accumulation of levels high enough to cause TTS or masking of biologically relevant sound for fishes is also extremely unlikely. As with the other stressors for fishes discussed in this section, exposure to the sound produced from weapons would only be expected to cause brief behavioral or stress responses should they detect the noise. Fish may

react by exhibiting startle responses, rapid bursts in movement, changes in swimming direction or orientation, or leaving the immediate area of the sound. Concurrent with these behavioral responses, fishes could also experience temporary increases in heart rate or stress hormones. However, any behavioral reactions and physiological stress would likely be brief, and are expected to return to normal shortly after the weapons noise ceases. Therefore, the effects on fishes from weapons noise are anticipated to be minor, temporary, and are not expected to lead to a significant disruption of normal behavioral patterns. Therefore, weapons noise exposure may cause short-term physiological stress or behavioral reactions, but these effects are considered insignificant and are not likely to adversely affect the following ESA-listed fish species: Atlantic sturgeon, Atlantic salmon, scalloped hammerhead sharks, giant manta rays, and oceanic whitetip.

Pile Driving

ESA-listed sea turtles and fish could be exposed to sounds from impact (installation only) and vibratory (installation and removal) pile driving during Port Damage Repair training activities throughout the year (pile driving would not occur during testing activities). Port Damage Repair training would occur over a period of five days, and up to four times per year (20 days total) in Gulfport, Mississippi (Navy 2024c). As a standard operating procedure, the Action Proponent performs soft starts at reduced energy during an initial set of strikes from an impact hammer (Navy 2024c). Soft starts may warn animals and cause them to move away from the sound source before impact pile driving increases to full operating capacity. Mitigation measures involving Navy Lookouts will also be implemented during pile driving activities (see Table 5 for details). Additional discussion of pile driving noise as a potential stressor is included in Section 2.4.1.

Sea Turtles

Sounds from impact and vibratory hammers used for pile driving are impulsive, broadband, and dominated by lower frequencies, which are within the hearing range of sea turtles. Popper et al. (2014) estimate the risk of sea turtles responding to impact pile driving is high at close range (tens of meters), moderate at intermediate range (hundreds of meters), and low at far range (thousands of meters) from the source. Based on prior observations of sea turtle reactions to sound, if a behavioral reaction were to occur, the responses would likely include increases in swim speed, change of position in the water column, or avoidance of the sound. There is no evidence to suggest that any behavioral response would persist after a sound exposure, and it is likely that a stress response would accompany any behavioral response.

Due to the low source level of vibratory pile extraction, the zone for potential masking would only extend a few hundred meters from where the source is operating (Navy 2024c). For impact pile driving, the rate of strikes (60 per minute) has the potential to result in some masking. However, the effect would be brief and temporary, lasting the amount of time it would take to drive a pile (a few minutes per pile), with pauses before the next pile is driven. Furthermore, Port Damage Repair training will occur in shallow, nearshore waters of a busy commercial port where ambient noise levels are already typically high (Navy 2024c). Given these factors, significant masking is unlikely to occur in sea turtles exposed to sound from pile driving or extraction.

Table 41 shows the predicted ranges to auditory injury (AINJ), TTS, and significant behavioral response for sea turtles from exposure to impact and vibratory pile driving. Results from the Navy's Acoustics Effects Model (NAEMO) quantitative analysis (discussed in Section 6.1.1) show that pile driving activities as part of the proposed action would result in zero instances of behavioral reaction, TTS, AINJ, injury or mortality to any ESA-listed sea turtles in the action area. The Navy's standard operating procedures to perform soft starts during impact installation of each pile (Section 2.3.1) and the proposed pile driving mitigation measures (Section 2.3.2) further reduce the likelihood that this stressor will adversely affect ESA-listed sea turtles.

In summary, while ESA-listed sea turtles may be exposed to pile driving noise, any behavioral or physiological response would likely be short-term, relatively minor, and would not result in a significant disruption of normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Therefore, the effects of pile driving noise on ESA-listed sea turtles are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of noise from pile driving activities resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles.

Table 41. Pile Driving Range to Effects for Sea Turtles (Navy 2024c)

<i>Pile Type/Size and Method</i>	<i>AINJ</i>	<i>TTS</i>	<i>BEH</i>
16" Timber/Plastic Piles using Impact Methods	5 m	46 m	5 m
16" Timber/Plastic Piles using Vibratory Methods	1 m	16 m	1 m
24" Steel Sheet Piles using Vibratory Methods	0 m	10 m	1 m

Notes: AINJ = auditory injury; TTS = temporary threshold shift; BEH = significant behavioral response

Fish

Pile driving activities conducted in Gulfport, Mississippi, have the potential to overlap areas where Gulf sturgeon, smalltooth sawfish, and giant manta rays would occur. No other ESA-listed fish species is expected to occur close enough to where pile driving will take place to be exposed to this stressor. Smalltooth sawfish primarily occur in southern Florida and would be a rare occurrence near Gulfport. Similarly, although some manta rays have been observed in estuarine waters near oceanic inlets, they are much less likely to occur in the inshore waters, particularly in the industrialize port area where pile driving will occur. Therefore, co-occurrence of sawfish or manta rays with pile driving during the limited time pile driving activities occur would be extremely unlikely (i.e., discountable). Assuming sturgeon may behave similarly to other resident or demersal (i.e., bottom-dwelling) fishes in nearshore areas, there is the potential for Gulf sturgeon to be exposed to pile driving for longer durations compared to species that are more pelagic (i.e., open water) and may transit through the area. Gulf sturgeon could be exposed to sounds from impact (installation only) and vibratory (install and removal) pile driving during port damage repair training activities at Gulfport, Mississippi throughout the year (pile driving

would not occur during testing activities). Port damage repair training would occur over five days and up to four times per year (20 days total).

Criteria and thresholds used to estimate impacts from sound produced by impact pile driving are shown in Table 42. Consistent with the *ANSI Sound Exposure Guideline* technical report (Popper et al. 2014), dual metric sound exposure criteria and cumulative sound exposure metrics are utilized to estimate ranges to mortality, non-auditory injury, and TTS (respectively) from impulsive sources. Ranges to effects for impact pile driving (Table 43) were determined by modeling the distance that sound would need to propagate to reach exposure level thresholds specific to a fish hearing group or category that would cause TTS, injury, and mortality. Modeling for pile driving was done outside of the Navy's Acoustic Effects Model (see the *Quantitative Analysis Technical Report* for details). The pile driving ranges for injury and mortality are SPL-based.

Based on the limited exposure likelihood, and very small calculated ranges to effects (i.e. with 1 m), it is extremely unlikely that Gulf sturgeon would be injured or killed as a result of this activity. Although TTS could occur for Gulf sturgeon within 21 m of impact pile driving, sturgeon would need to remain within this range during all impact pile driving (up to four piles in a day) to receive this effect. Furthermore, the use of soft start procedures would reduce any of these effects as Gulf sturgeon would likely avoid the immediate area as the activity ramps up. More likely, some minor behavioral reactions (e.g., increasing their swimming speed, moving away from the source, or not responding at all), physiological stress, or masking may occur during impact or vibratory pile driving activities. Such effects would be expected to be brief, lasting the duration it takes to drive a pile, and would only occur a maximum of 20 days in a year. Additionally, masking from impulsive sounds from impact pile driving would be low due to the extremely brief duration of each individual impulse. More likely, masking effects could occur during installation or removal of piles using vibratory methods. However, these effects would be limited to the time the vibratory hammer is operated (several minutes at most) during which the pile driving noise could temporarily limit the distance over which fishes can communicate or detect important signals, or sturgeon may respond by altering their vocalizations to compensate for the noise.

In summary, while Gulf sturgeon may be exposed to pile driving noise, any behavioral or physiological response would likely be short-term, relatively minor, and would not result in a significant disruption of normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Therefore, the effects of pile driving noise on Gulf sturgeon are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of noise from pile driving activities resulting from the proposed action may affect, but are not likely to adversely affect Gulf sturgeon.

Table 42. Sound Exposure Criteria for Pile Driving (Navy 2024c)

<i>Fish Category</i>	<i>Mortality</i>		<i>Injury</i>		<i>TTS</i>
	<i>cSEL</i>	<i>peak SPL</i>	<i>cSEL</i>	<i>peak SPL</i>	<i>cSEL</i>
Pile Driving / Air Guns					
Fishes without a swim bladder	> 219	> 213	> 216	> 213	NC
Fishes with a swim bladder	210	> 207	203	> 207	> 186
Fishes with a swim bladder involved in hearing and those with high-frequency hearing ¹	207	> 207	203	> 207	186

¹ Hearing specialists. All other groups are considered hearing generalists.

Notes: cSEL = cumulative SPL (dB re 1 μ Pa²-s); peak SPL = average single strike peak sound pressure level (dB re 1 μ Pa); TTS = temporary threshold shift; NC = effects from exposure to impulsive sources are unlikely, therefore no criteria are proposed; “>” indicates that the given effect would occur above the reported threshold.

Table 43. Impact Ranges for Resident Fishes from Impact Pile Driving (one day) (Navy 2024c)

<i>Fish Category</i>	<i>Range to Effects (meters)</i>				
	<i>Onset of Mortality</i>		<i>Onset of Injury</i>		<i>TTS</i>
	<i>cSEL</i>	<i>Peak SPL</i>	<i>cSEL</i>	<i>Peak SPL</i>	<i>cSEL</i>
Fishes without a swim bladder	0	0	0	0	0
Fishes with a swim bladder not involved in hearing	0	0	2	0	< 15
Fishes with a swim bladder involved in hearing and high-frequency hearing	1	0	2	0	15

Notes: cSEL = Cumulative sound exposure level, peak SPL = 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.

Elasmobranchs (e.g., sharks, rays, and sawfish), like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Popper and Schilt 2009). The lateral line system, a specialized sensory organ in fish, allows them to detect subtle water motions and pressure gradients. Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Myrberg Jr. 2001; Yan 2003; Casper 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). However, unlike most teleost (i.e., bony) fish, elasmobranchs do not have swim bladders (or any other air-filled cavity), and thus are unable to detect sound pressure (Casper et al. 2012). Particle motion is presumably the only sound stimulus that can be detected by elasmobranchs (Casper et al. 2012). Given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low frequency sound from the pile driving if exposed. However, the duration and intensity of low-frequency acoustic stressors and the implementation of conservation measures will likely minimize the effect this stressor has on elasmobranchs. Furthermore, although some elasmobranchs have been known to respond to

anthropogenic sound, in general elasmobranchs are not considered particularly sensitive to sound (Casper et al. 2012). Overall, these reactions are unlikely to lead to a significant disruption of normal behavior patterns such as breeding, feeding, or sheltering. Thus, while ESA-listed elasmobranchs may be exposed to pile driving noise, any behavioral or physiological response would likely be short-term, relatively minor, and would not result in a significant disruption of normal behavior patterns. Therefore, the effects of pile driving noise on ESA-listed elasmobranchs are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of noise from pile driving activities resulting from the proposed action may affect, but are not likely to adversely affect the giant manta ray or smalltooth sawfish.

Energy Stressors

The only energy stressor that may affect ESA-listed species is in-water electromagnetic devices. For the 2018 AFTT Phase III consultation, we also analyzed the effects of high-energy lasers, which we determined may affect but were not likely to adversely affect ESA-listed species. However, for Phase IV the Action Proponents have provided new information indicating that when contact with the target (i.e., surface vessel) is lost, the lasers automatically turn off, thereby removing any potential to impact marine resources. Therefore, based on the new information regarding how Navy lasers operate, we no longer consider this to be a “may affect” stressor and do not analyze it here.

In-water Electromagnetic Devices

Offshore training and testing activities that use in-water electromagnetic devices would occur in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf Range Complexes, and the Naval Surface Warfare Center Panama City Division Testing Range. In addition, training activities that use in-water electromagnetic devices would occur in the VACAPES Range Complex Inshore and Hampton Roads areas, and several port and pierside locations. Additional discussion of in-water electromagnetic devices as a potential stressor is included in Section 2.4.3.

Marine Mammals

Normandeau et al. (2011) concluded there was behavioral, anatomical, and theoretical evidence indicating cetaceans sense magnetic fields. Fin, humpback, and sperm whales have shown positive correlations with geomagnetic field differences. Although none of the studies have determined the mechanism for magneto-sensitivity, the suggestion from these studies is that whales can sense the Earth’s magnetic field and may use it to migrate long distances. Most of the evidence of cetaceans sensing magnetic fields is indirect evidence from correlation of sighting and stranding locations suggesting that cetaceans may be influenced by local variation in the earth’s magnetic field (Klinowska 1985; Kirschvink 1990; Walker et al. 1992). Cetaceans appear to use the Earth’s magnetic field for migration in two ways: as a map by moving parallel to the

contours of the local field topography, and as a timer based on the regular fluctuations in the field allowing animals to monitor their progress on this map (Klinowska 1990).

If a marine mammal was in proximity of an electromagnetic field source associated with training or testing, emitting a field strong enough to be detected, and that animal is sensitive to the exposure, it is conceivable that the electromagnetic field could have an effect on a marine mammal, primarily impacting that animal's navigation. Impacts to marine mammals associated with electromagnetic fields are dependent on the animal's proximity to the source and the strength of the magnetic field. Electromagnetic fields associated with AFTT activities are relatively weak (only 10% of the earth's magnetic field at 24 m), temporary, and localized (Navy 2024c). Once the source is turned off or moves from the location, the electromagnetic field is gone. A marine mammal would have to be present within the electromagnetic field (approximately 200 m from the source) during the activity in order to detect it, though detection does not necessarily signify a significant biological response. Given the small area associated with mine fields, the infrequency and short duration of magnetic energy use, the low intensity of electromagnetic energy sources (essentially mimicking the magnetic field of a steel vessel), and the anticipated density of marine mammals in these areas, we consider it extremely unlikely that an ESA-listed marine mammal would be exposed to electromagnetic energy at sufficient intensities to create an adverse effect through behavioral disruption or otherwise. Therefore, potential effects from electromagnetic devices are discountable. Thus, we conclude that the effects of in-water electromagnetic devices resulting from the proposed action may affect, but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

Sea Turtles

Magnetic fields and other cues (e.g., visual cues), are known to be important for sea turtle orientation and navigation (Lohmann et al. 2000; Putman et al. 2015). Sea turtles use geomagnetic fields to navigate at sea, and therefore changes in those fields could impact their movement patterns (Lohmann and Lohmann 1996; Lohmann and Lohmann 1998). Turtles in all life stages orient to the earth's magnetic field to position themselves in oceanic currents and directional swimming presumably aided by magnetic orientation has been shown to occur in some sea turtles (Christiansen et al. 2016). This life strategy enables them to locate seasonal feeding and breeding grounds and return to their nesting sites (Lohmann and Lohmann 1996; Lohmann and Lohmann 1998). Sea turtles have been shown able to detect changes in magnetic fields, which may cause them to deviate from their original direction (Lohmann and Lohmann 1996). For example, Liboff (2016) determined that freshly hatched sea turtles are able to detect and use the local geomagnetic field as a reference point before embarking a post-hatchling migration. This study suggests that the information is transferred from the mother to the egg through some undetermined geomagnetic imprinting process.

Sea turtles may also use nonmagnetic cues for navigation and migration, and these additional cues may compensate for variations in magnetic fields. Putman et al. (2015) conducted experiments on loggerhead hatchlings and determined that electromagnetic fields may be more important for sea turtle navigation in areas that may constrain a turtle's ability to navigate by other means (cold temperatures or displacement from a migration route). The findings of this study suggest that the magnetic orientation behavior of sea turtles is closely associated with ocean ecology and geomagnetic environment (Putman et al. 2015). Other studies on behavioral responses of sea turtles to magnetic fields have been conducted on green and loggerhead sea turtles (Normandeau et al. 2011). Loggerhead sea turtles have been shown to be sensitive to electromagnetic field intensities ranging from 0.005 to 4,000 microteslas. Green turtles were found to be sensitive to field intensities from 29.3 to 200 microteslas. Although data is lacking for other sea turtle species, the sensitivities of loggerhead and green turtles is assumed similar to other species.

As stated above, the static magnetic fields generated by electromagnetic devices used in AFTT activities are of relatively minute strength. The maximum strength of the magnetic field is approximately 2,300 microteslas, with the strength of the field decreasing further from the device. At a distance of 4 m from the source of a 2,300 microtesla magnetic field, the strength of the field is approximately 50 microteslas, which is within the range of the Earth's magnetic field (25 to 65 microteslas). At 8 m, the strength of the field is approximately 40% of the Earth's magnetic field, and only 10% at 24 m away from a 2,300 microtesla magnetic field (Navy 2024c). Therefore, at a distance of 200 m (the maximum predicted distance of the magnetic field proposed for use by the Navy) the strength of the magnetic field would be approximately 0.2 microteslas (Navy 2024c), which is less than 1% of the strength of the Earth's magnetic field. This is likely within the range of detection for sea turtle species, but at the lower end of their sensitivity to the field.

For any sea turtles located in the immediate area (within approximately 200 m) where in-water electromagnetic devices are being used, adult, sub-adult, juveniles, and hatchling sea turtles could be temporarily disoriented and could deviate from their original movements, but the extent of this disturbance is likely to be inconsequential given the brief duration of the potential disorientation (seconds or minutes). These brief behavioral disruptions are expected to be limited and minor, and not anticipated to result in any significant effect, beyond what would be similar to natural stressors regularly occurring in the animal's life cycle. Therefore, the effects from exposure to in-water electromagnetic devices for sea turtles are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of in-water electromagnetic devices resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles.

Fish

ESA-listed fish in the action area may encounter in-water electromagnetic devices during training and testing activities. The static magnetic fields generated by electromagnetic devices used in AFTT activities are of relatively minute strength. The maximum strength of the magnetic field is approximately 2,300 microteslas, with the strength of the field decreasing further from the device. At a distance of 4 m from the source of a 2,300 microtesla magnetic field, the strength of the field is approximately 50 microteslas, which is within the range of the Earth's magnetic field (25 to 65 microteslas). At 8 m, the strength of the field is approximately 40% of the Earth's magnetic field, and only 10% at 24 m away from a 2,300 microtesla magnetic field (Navy 2024c). Therefore, at a distance of 200 m (the maximum predicted distance of the magnetic field proposed for use by the Navy) the strength of the magnetic field would be approximately 0.2 microteslas (Navy 2024c), which is less than 1% of the strength of the Earth's magnetic field.

Fish have been shown to be sensitive to electromagnetic fields, based upon their orientation in the water column and prey location (Kirschvink 1997; Tricas and New 1997). However, it is generally accepted that the limited levels of electromagnetic fields from small numbers of marine renewable energy devices are unlikely to significantly affect fish (Gill et al. 2014; Gill and Desender 2020). The species most commonly studied for electromagnetic field sensitivity include elasmobranchs (sharks, skates, and rays), agnatha (lampreys), and bony fish (teleosts and chondrosteans). Elasmobranchs (rays, skates, sharks) are particularly sensitive to electromagnetic fields as they use electromagnetic-receptive sensory systems for orientation, navigation, and locating conspecifics or buried prey.

Exposures to relatively high strength magnetic fields for days to weeks can have physiological effects on organisms. Formicki et al. (2019) reviewed effects on spermatozoa movement, fertilization rates, and egg incubation period in a range of fish species, and Juutilainen (2005) reports developmental effects in fish and sea urchin embryos from exposure to magnetic fields in the range of 0.1–10 microteslas. In addition, natural diurnal weak magnetic field variation could play a role in organisms' internal clocks, and magnetic disturbances may hence be able to cause chronobiologic disruptions, with potential health consequences for the organism (Liboff 2014) and effects of anthropogenic magnetic fields on homeostatic and metabolic functions have been suggested (Begall et al. 2013). Also, distorted magnetic fields during developmental phases have resulted in failed magnetic orientation later in life, perhaps by effects on an internal magnetic map, in loggerhead sea turtles and rainbow trout (Fuxjager et al. 2014; Putman et al. 2015). However, such long-term exposure effects are likely not relevant in the context of the AFTT electromagnetic energy emissions which only disturb animals for a short period (minutes to hours). Any behavioral or physiological response would likely be short-term, relatively minor, and would not result in a significant disruption of normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering

In summary, while ESA-listed fishes may be exposed to in-water electromagnetic devices during training and testing activities the effects would be discountable because of: (1) the relatively low

intensity of the magnetic fields generated (0.2 microteslas 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). Therefore, the effects of in-water electromagnetic devices on ESA-listed fishes are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of in-water electromagnetic producing activities resulting from the proposed action may affect, but are not likely to adversely affect the following species: Nassau grouper, shortnose sturgeon, Atlantic sturgeon, Atlantic salmon, scalloped hammerhead sharks, giant manta rays, smalltooth sawfish and oceanic whitetip sharks.

Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance, including the potential for strike, during military readiness training and testing activities within the action area from: in-water devices; military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions; and seafloor devices.

In-water Devices (excluding Unmanned Surface Vehicles)

In-water devices are used in both offshore and inshore portions of the action area and could pose a collision risk to ESA-listed species. Additional discussion of in-water devices as a potential stressor is included in Section 2.4.4.

Given their size and potential operating speed, unmanned surface vehicles are the in-water devices with the most potential to strike living marine resources. The risk of an unmanned surface vehicle striking an ESA-listed species will be analyzed, along with the risk of a manned vessel strike, in our Analysis of Effects section (Section 6) below.

Marine Mammals

Most devices do not have a realistic potential to strike living marine resources because they either move very 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 (Navy 2024c).

Despite thousands of Action Proponent exercises in which in-water devices have been used, there have been no recorded instances of a marine mammal strike from these devices. In addition, the Action Proponents will implement mitigation, as described in Section 2.3.2, to further minimize the potential risk of an in-water device striking a marine mammal. For these reasons, we consider it extremely unlikely for any ESA-listed marine mammal to be struck by an in-water device. It is possible that marine mammals that occur in areas that overlap with in-water device use may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that the effects to the individual exposed would be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Therefore, potential effects on ESA-listed marine mammals from in-water devices are discountable, in the case of strike risk, and insignificant in the case of behavioral disturbance. Thus, we conclude that the effects of in-water devices (excluding unmanned surface vehicles) resulting from the proposed action may affect,

but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

Sea Turtles

As discussed above for marine mammals, with the exception of unmanned surface vehicles (which are discussed below in Analysis of Effects), it is extremely unlikely that an in-water device will strike a sea turtle because the proposed devices either move too slowly through the water column, or are closely monitored by an observer to ensure the towed device does not run into objects in the water (Navy 2024c). The Action Proponents will also implement mitigation, as described in Section 2.3.2, to further minimize the potential risk of an in-water device striking a sea turtle. It is possible that sea turtles occurring in areas that overlap areas where in-water devices are used may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that the effects to the individual exposed would be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Therefore, potential effects on ESA-listed sea turtles from in-water devices are discountable, in the case of strike risk, and insignificant in the case of behavioral disturbance. Thus, we conclude that the effects of in-water devices (excluding unmanned surface vehicles) resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles.

Fish

Overall, ESA-listed fish are not at risk of in-water device strikes due to proposed action training and testing activities throughout the majority of the action area. However, in some portions of the action area, particularly inshore areas, ESA-listed fish may overlap spatially with AFTT in-water devices. As discussed above for sea turtles, with the exception of unmanned surface vehicles (which are discussed below in the Analysis of Effects section), it is extremely unlikely that an in-water device will strike an ESA-listed fish because the proposed devices either move too slowly through the water column, or are closely monitored by an observer to ensure the towed device does not run into objects in the water (Navy 2024c). In addition, there has never been a recorded incidence of a Navy in-water device striking an ESA-listed fish. It is possible that ESA-listed fish occurring in areas that overlap areas where in-water devices are used may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that the effects to the individual exposed would be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Therefore, potential effects on ESA-listed fish from in-water devices are discountable, in the case of strike risk, and insignificant in the case of behavioral disturbance. Thus, we conclude that the effects of in-water devices (excluding unmanned surface vehicles) resulting from the proposed action may affect, but are not likely to

adversely affect the following species: Nassau grouper, shortnose sturgeon, Atlantic sturgeon, Atlantic salmon, scalloped hammerhead sharks, giant manta rays, smalltooth sawfish and oceanic whitetip sharks.

Invertebrates

ESA-listed coral species, including boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, and staghorn coral, are particularly vulnerable to physical disturbance. These species rely on stable, hard substrate habitats that are protected under the established mitigation protocols (Section 2.3 Mitigation Measures). Naval operations in sensitive marine environments employ specific standard operating procedures and mitigation measures to protect benthic organisms and their habitats. The primary protective measure requires vessels and in-water devices to maintain a minimum clearance of 1 ft above the seafloor in the KWRC and SFOMF. This requirement serves as a critical safeguard for ESA-listed coral species and queen conch populations that inhabit these areas. Additionally, standard operating procedures, employed throughout the action area, emphasize avoiding proximity to hard structures that could potentially damage vessels or in-water devices, providing an additional layer of protection for coral reef ecosystems. The implementation of these protective measures effectively minimizes direct impacts on adult coral colonies and queen conch populations.

The potential for in-water device and small vessel interactions with invertebrate larvae must be considered within the context of natural dispersal patterns. Coral larvae demonstrate complex dispersal behaviors that can range from local retention to long-distance transport. Similarly, queen conch larvae undergo considerable dispersal during their planktonic phase, though recent research indicates some historical ecological corridors for larval flow have been compromised (Horn et al. 2022). The sporadic nature of vessel movements through these waters, combined with the vast volume of the marine environment, suggests that any potential disturbance would be both localized and infrequent.

In summary, the established protective measures, particularly the one-foot clearance requirement and avoidance of hard substrate areas, provide substantial protection for adult queen conch and ESA-listed coral such that we find it extremely unlikely that an AFTT in-water device or vessel would strike one of these species. While there is potential for larval disturbance from in-water devices or vessels, any effects would be insignificant given the minimal spatial overlap anticipated. Therefore, effects from in-water devices and vessel use during AFTT activities may affect, but are not likely to adversely affect, boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, staghorn coral, or queen conch.

Military Expended Materials

Training and testing activities in the action 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 and testing events with ship hulks (Navy 2024c). During these training and testing activities, various types of munitions and non-

munitions may be introduced and expended into the marine environment, which collectively are referred to as military expended materials. Additional discussion of military expended materials as a potential stressor is included in Section 2.4.4.

This section analyzes the strike potential to ESA-listed species 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. The primary concern is the potential for an animal to be hit with a military expended material at or near the water's surface, which could result in injury or death. The physics of projectile movement through water significantly influences strike probability. When military expended materials such as projectiles, bombs, missiles, and rockets impact the water's surface, they experience rapid deceleration due to water resistance. This dramatic reduction in velocity creates a distinct pattern of strike risk zones: highest risk at the surface impact point, decreasing risk through the water column, and minimal risk by the time materials reach the seafloor. The rapid velocity decrease provides a critical safety factor for most water column species. While disturbance or strike from an item falling through the water column is possible, it is considered extremely unlikely because the objects generally sink slowly through the water based on the weights of expended materials and can be avoided by ESA-listed marine mammals, sea turtles, and fish. Therefore, the discussion of military expended material strikes for these species groups focuses on the potential of a strike at or near the surface of the water. For corals and queen conch we also discuss the impacts of military expended materials that sink to the seafloor. Military expended materials resulting from the detonation of in-water explosives are discussed in our Analysis of Effects in Section 6.

Marine Mammals

While no strike of marine mammals from military expended materials has ever been reported or recorded, the possibility of a strike still exists. The Action Proponents estimated potential direct strike exposures based on a modeled scenario using the following areas with the highest amounts of military expended material expenditures: VACAPES and JAX Range Complexes, and the Southeast U.S. Gulf of America Region including Panama City Division Testing Range and Key West Range Complex. Estimates were made for each of the endangered marine mammal species found in the areas where the highest levels of military expended materials would be expended. Input values include materials data (frequency, footprint, and type), size of the training or testing area, marine mammal density data, and size of the animal. To estimate the potential of military expended materials to strike a marine mammal, the impact area of each category of military expended materials analyzed for marine mammals was totaled over one year in the area with highest combined amounts of military expended materials. The results indicate that it is extremely unlikely that an ESA-listed marine mammal would be struck by military expended materials as a result of the proposed action. For details on this approach, we refer the reader to Section 4.4.2.3.4 (pp. 4-650 to 4-653) of the AFTT BA, which we incorporate here by reference (Navy 2024c). The Action Proponents will also implement mitigation measures, as described in

Section 2.3.2, to further minimize the potential risk of military expended materials striking a marine mammal.

In summary, we consider it extremely unlikely for any ESA-listed marine mammal to be struck by military expended materials. Any individuals encountering military expended materials as they fall through the water column are likely to move to avoid them. Given the effort expended by individuals to avoid them will be minimal (i.e., a few meters distance) and temporary, behavioral avoidance of military expended materials sinking through the water column is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). For these reasons, the effects on ESA-listed marine mammals from military expended materials are insignificant, in the case of behavioral disturbance, or discountable, in the case of strike. Thus, we conclude that the effects of military expended materials resulting from the proposed action may affect, but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

Sea Turtles

AFTT activities involving military expended materials occur both nearshore and offshore along the Atlantic coast, but the majority of materials would be expended in offshore areas. During AFTT activities that produce military expended materials, the potential for a strike of ESA-listed sea turtles exists from all sizes of non-explosive practice munitions, fragments from high-explosive munitions, expendable targets, and expended materials other than munitions; such as sonobuoys, expended bathythermographs, and torpedo accessories. The chance of a sea turtle being hit is related to the sea turtle's life history and likelihood of presence in the portions of the action area where such materials will be expended. The primary concern with these materials is for a sea turtle located at or near the water surface to be struck. If this occurs, a sea turtle could be injured or killed.

For training and testing activities occurring in offshore waters, the species and age classes most likely to be impacted are hatchlings and pre-recruitment juveniles of all sea turtle species, adult loggerhead turtles, and leatherback turtles of all age classes. Adult sea turtles in these areas could be located at the surface, but generally spend most of their time submerged. Thus, adult sea turtles are expected to be at the surface for brief periods of time compared to hatchlings and juveniles, as these early life stages spend more time at the surface while in ocean currents. However, all life stages do spend some time at the surface basking. Because the Navy will not commence activities that expend materials (e.g. weapons firing) near concentrated *Sargassum* mats, the chances of these life stages being affected is relatively low.

Using the same approach as described above for marine mammals, the Action Proponents estimated potential direct strike exposures to sea turtles based on a modeled scenario (Navy 2024c). The estimated annual strike exposures to green sea turtles from military expended materials in the VACAPES Range Complex was 0.085 individuals for training and 0.062 for testing activities. For loggerhead sea turtles in the JAX Range Complex, the strike exposures from military expended materials were 0.151 individuals for training and 0.097 individuals for

testing activities (Navy 2024c). The direct strike exposures over seven years, calculated using the same method as the one year exposures, were as follows: green sea turtle in VACAPES Range Complex - training = 0.436 / testing = 0.241; loggerhead sea turtle in JAX Range Complex - training = 0.544 / testing = 0.208 (Navy 2024a).

Based on the quantitative analysis, while the probability of striking a sea turtle in any given year is very low, over multiple years it is possible that a few turtles could be struck by military expended materials. However, to fully evaluate the likelihood of such a strike occurring as a result of the proposed action, we also need to consider the underlying assumptions that went into this analysis. Green sea turtles were used for the VACAPES Range Complex and loggerhead sea turtles were used for the JAX Range Complex, as a proxy species for modeling impacts, because these sea turtle species have the highest seasonal densities in the corresponding areas. Therefore, the probability of striking one of these species in a different location or time of year, or of striking a different species of sea turtle would be lower; and considerably lower for many location/season/species combinations. The analysis also assumes that sea turtles would be at or near the surface 100% of the time, when in fact adult green and loggerhead sea turtles spend a large amount of time below the surface (particularly when foraging), where they would not be exposed to military expended materials at the surface. The quantitative analysis also does not take into account that most projectiles fired during training and testing activities are fired at targets, and so only a very small portion of those projectiles that miss the target would hit the water with their maximum velocity and force. The analysis also does not take into account the possibility that sea turtles may actively avoid areas where military activities involving expended materials are being used.

In addition to these assumptions, we note that the Action Proponents have never reported a sea turtle strike as a result of military expended materials in the AFTT action area or any other action area where military readiness training and testing occurs. Standard mitigation involving Lookouts during such activities, which was not accounted for in the quantitative analysis, may further reduce the likelihood of sea turtle exposure to a direct strike from a military expended material. In particular, small sea turtles associated *Sargassum* habitat are not likely to be struck because of mitigation requirements to avoid expending materials (e.g. weapons firing) near concentrated mats.

In summary, the quantitative analysis predicted a very small number (i.e., less than one every seven years) of green or loggerhead sea turtles could be directly struck by military expended materials as a result of the proposed action. However, based on the modeled assumptions and other factors discussed above, we believe the quantitative analysis overestimates the likelihood of such a strike occurring. We, therefore, find a direct strike of a green or loggerhead sea turtle by a military expended material to be extremely unlikely. Since other sea turtle species occur in lower densities (compared to the densities modeled for greens and loggerhead), we also find that a direct strike of a hawksbill, leatherback, or Kemp's ridley sea turtle by a military expended material to be extremely unlikely. Any individual sea turtles encountering military expended materials as they fall through the water column are likely to move to avoid them. Given the effort expended by individuals to avoid them will be minimal (i.e., a few meters distance) and

temporary, behavioral avoidance of military expended materials sinking through the water column is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). For these reasons, the effects on ESA-listed sea turtles from military expended materials are insignificant, in the case of behavioral disturbance, or discountable, in the case of strike. Thus, we conclude that the effects of military expended materials resulting from the proposed action may affect, but are not likely to adversely affect the following sea turtle species: green – North Atlantic DPS, loggerhead Northwest Atlantic DPS, hawksbill, leatherback, or Kemp’s ridley.

Fish

Most fish species possess natural avoidance capabilities that help mitigate strike risks from military expended materials. Their lateral line systems and other sensory mechanisms allow them to detect approaching objects through water displacement and pressure changes. As expended materials lose momentum while traveling through the water column, fish have increasing opportunity to detect and avoid these objects. This natural avoidance capability becomes more effective as projectile velocity decreases, though surface-dwelling species have less reaction time during initial impact events.

While no strike of ESA-listed fish species from military expended materials has ever been reported or recorded, the possibility of a strike still exists. The probability of direct strikes must be considered within the context of species abundance and distribution patterns. Given the vast expanse of the action area, the relatively localized nature of training activities, and the anticipated low density of ESA-listed fish in areas where AFTT activities involving military expended materials will occur, the likelihood of strikes affecting ESA-listed species is considerably lower than for more abundant non-listed species. Even in scenarios involving intensive training activities, such as small-caliber projectile exercises within a confined gunnery box, the mathematical probability of striking an individual ESA-listed fish remains extremely low.

Analysis of military expended material strike risks involves a complex interaction between physical factors and biological characteristics. Different fish species exhibit varying levels of vulnerability to fragment strikes based on their physical characteristics and position in the water column. Factors such as body size, scale thickness, and swimming capabilities influence their susceptibility to injury from explosive fragments. Fish with greater mobility may have better chances of avoiding fragments as they disperse through the water column. 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. Marine environments where military training and testing operations occur contain multiple fish species that frequent surface waters, making them potentially vulnerable to strikes from expended materials. Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks, and giant manta rays are particularly at risk due to their surface-oriented behavior patterns in offshore and continental shelf areas. These species often occupy the upper water column where they may encounter military expended materials during their initial impact with the water's surface. While surface-dwelling species face the highest immediate risk

due to their proximity to impact points, the rapid deceleration of materials in water significantly reduces risks to water column species. As military expended materials settle to the seafloor, they create potential strike risks for bottom-dwelling species. Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, Nassau grouper, and smalltooth sawfish inhabit benthic environments where they may encounter settling materials.

The combination of natural avoidance capabilities, rapid projectile deceleration in water, and the relatively low density of ESA-listed species suggests that while strike risks exist, the likelihood of a military expended material strike is extremely low. Given the effort expended by individuals to avoid military expended materials as they sink in the water column will be minimal (i.e., a few meters distance) and temporary, behavioral avoidance of military expended materials sinking through the water column is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

For these reasons, the effects on ESA-listed fish from military expended materials are insignificant, in the case of behavioral disturbance, and discountable, in the case of strike. Thus, we conclude that the effects of military expended materials resulting from the proposed action may affect, but are not likely to adversely affect the following fish species: Atlantic sturgeon DPSs, shortnose sturgeon, Gulf sturgeon, Nassau grouper, smalltooth sawfish, Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks Central and Southwest Atlantic DPS, and giant manta rays.

Invertebrates

Military expended materials in the KWRC (offshore and inshore locations) and the South Florida Ocean Measurement Facility may impact ESA-listed coral species, coral critical habitat and queen conch. The effects of the proposed action on coral critical habitat are discussed below in Section 4.1.3.

The mitigation measures identified in Section 2.3.2 will reduce or eliminate the potential physical disturbance by locating some military expended materials away from ESA-listed coral species and reef-associated species. Both explosive and non-explosive munitions against surface targets (e.g., ship hulk) will not be used near mapped shallow-water coral reefs, including deeper water coral reefs in the KWRC (e.g., Pulley Ridge). Mapped ESA-listed invertebrate habitat only occurs within mitigation areas with protective measures preventing explosive and non-explosive munitions use against surface targets. The vast majority of the KWRC is too deep for queen conch.

In shallow water queen conch habitat, the impact of munitions against a surface target would be limited by the distance from shore (e.g., most heavy munitions limited to areas seaward of state coastal waters and in some cases Federal waters as well) which places most impacts seaward of dynamic nearshore habitats. The vast majority of the KWRC and SFOMF is too deep for queen conch. Shallow seafloor areas where queen conch may occur are also located mostly in the Florida Keys National Marine Sanctuary where the Action Proponents have agreed not to release

military expended materials, with a few exceptions. The exceptions include military expended materials associated with explosion ordnance disposal training (e.g., limpet mines, mine shapes) proposed for Demolition Key (an inshore location within the KWRC). In Demolition Key, a number of mine shapes may be expended on shallow soft bottom habitats mostly devoid of seagrass beds and other structured habitats. The effects of military expended materials and other stressors on ESA-listed invertebrates (i.e., corals and queen conch) resulting from in-water explosives detonations are discussed in Section 6.4.2.

Military expended materials other than munitions from offshore training and testing activities may drift into the habitat of ESA-listed coral species and queen conch. Those items include mostly chaff and flares components (e.g., endcaps, pistons, O-rings, cartridges) and sonobuoys/sonobuoy components (e.g., wire, decelerators/parachutes). A study modeling the fate of military expended materials under the prevailing oceanographic condition (e.g., currents) in the KWRC found that materials were unlikely to travel into elkhorn and staghorn critical habitat regardless of sinking (U.S. Department of the Navy 2023). In addition, activities involving decelerators/parachutes are proposed to occur within Range Complexes, which begin at 3 NM from shore, and the majorities of activities that use decelerators/parachutes will typically occur even further offshore (at least 12-15 NM). Given the scarcity of ESA-listed corals in the nearshore portions of the action area, the offshore location of most military expended materials, and the prevailing ocean conditions, we find it extremely unlikely that military expended materials other than munitions (e.g., endcaps, pistons, O-rings, cartridges, wire, and decelerators/parachutes) will affect ESA-listed corals.

With the exception of mine neutralization and explosive ordnance disposal training that occurs in the operating areas and an associated inshore location of the KWRC (discussed in Section 6.4.2), munitions and other materials are primarily expended far from shore where they may only impact coral reefs in mesophotic habitats (water depths to 90 m). Munitions against a surface target would not be planned near shallow-water coral reefs, but the targets used for training in the KWRC are air-based and targeted with various munitions that could settle on Pulley Ridge. With testing activities, there are a smaller number of surface targets expended in the KWRC, but those activities would avoid the mapped shallow-water coral reefs.

Including both cases, the total annual footprint impacting shallow-water coral reefs would be approximately 0.13 acres (refer to Appendix I, Military Expended Material and Direct Strike Impact Analysis, of the AFTT Supplemental EIS/OEIS for quantitative analysis). However, the potential impact on ESA-listed coral species depends on their coverage on the habitat and where exactly in the range complex the material lands. For example, the coverage of living hard corals on Pulley Ridge averaged 1.5% (Reed et al. 2019) and most expended materials are expended in the operating areas (U.S. Department of the Navy 2023) where there is very little habitat for ESA-listed coral species or queen conch. Considering ESA-listed coral species are relatively rare among other live hard coral species, the chance of military expended materials striking or settling on a living colony of an ESA-listed coral species is so remote as to be discountable. The

chance of lighter materials (e.g., plastic, Styrofoam) expended offshore drifting in towards shore and settling on ESA-listed coral species or queen conch in shallow water is also extremely unlikely due to the oceanic currents in the area (e.g., Loop Current, Florida Current) (U.S. Department of the Navy 2023).

In summary, with the exception of military expended materials produced by in-water explosives, the effects of military expended materials from AFTT activities may affect, but are not likely to adversely affect, boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, staghorn coral, or queen conch. The effects of military expended materials produced by in-water explosives in shallow water on coral and queen conch are discussed in Section 6.4.2.

Seafloor Devices

Seafloor devices associated with the proposed action 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. Additional discussion of seafloor devices as a potential stressor is included in Section 2.4.4.

Marine Mammals

Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile animals. Objects falling through the water column will slow in velocity as they sink toward the bottom and would be avoided by ESA-listed marine mammals. The only seafloor device used during training and testing activities that has the potential to strike an ESA-listed marine mammal at or near the surface is an aircraft deployed mine shape, which is used during aerial mine laying activities. These devices are identical to non-explosive practice bombs, and the analysis of the potential impacts from those devices are covered above in Section 4.1.1.

Military Expended Materials. We consider it extremely unlikely for any ESA-listed marine mammals to be struck by a seafloor device. Therefore, potential effects on ESA-listed marine mammals from seafloor device strike are discountable. Any individuals encountering seafloor devices are likely to behaviorally avoid them. Given the slow movement and relatively small size of seafloor devices, the effort expended by individuals to avoid them will be minimal and temporary, and will not have fitness consequences. Any avoidance behavior would be of short duration and intensity such that the effects to the individual exposed would be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of seafloor devices resulting from the proposed action may affect, but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

Sea Turtles

Sea turtles could potentially be exposed to seafloor devices when foraging in benthic habitats (e.g., Kemp's ridley, loggerhead, hawksbill, and green sea turtles) or throughout the water

column in deep waters (e.g., leatherback sea turtle). Additionally, some sea turtle species in coastal habitats can occur near the bottom when resting. For activities that occur in offshore waters, the species and age classes that may be impacted by seafloor devices are juvenile, sub-adult, and adult loggerhead, green, and hawksbill turtles, especially if seafloor devices are placed in waters where the depths are within benthic foraging ability dive depths. The loggerhead sea turtle is the most abundant species in the VACAPES Range Complex, and adults may be found foraging in waters as deep as 200 m (Rieth et al. 2011; Hochscheid 2014). Juvenile sea turtles, such as green turtles may also rest and forage in waters as deep as 30 m (Rieth et al. 2011; Hochscheid 2014), and hawksbill turtles have been recorded at dive depths of 80 m. Juvenile and adult leatherback turtles are more likely to co-occur where seafloor devices are used in offshore areas given their preference for open-ocean habitats and feeding throughout the water column, and may dive to depths greater than 1,000 m. All sea turtle species are expected to be greatly dispersed throughout offshore waters of the action area.

For nearshore activities, juvenile, sub-adult, and adult leatherback and loggerhead sea turtles, as well as green, Kemp's ridley, and hawksbill sea turtles that are located in benthic foraging habitats, are most likely to be affected by seafloor devices since this is where the devices are used. However, the likelihood of a sea turtle encountering and being disturbed by a seafloor device in benthic foraging habitats is low because these devices are either stationary or move very slowly along the bottom, making them easily avoidable by a sea turtle. Sea turtles would be expected to ignore or avoid any slowly moving or stationary seafloor device. Given the slow movement of seafloor devices, the effort expended by sea turtles to avoid them will be minimal, and behavioral impacts will be temporary and insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of seafloor devices resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles.

Fish

The deployment of various devices on the seafloor during military operations introduces potential interaction risks with marine fish populations. These interactions merit careful examination to understand their ecological implications and assess the actual level of risk posed to different fish species. Fish demonstrate natural behavioral tendencies to aggregate around structures in the water column. Static fish aggregating devices (FADs), which are anchored to the seafloor, serve as primary examples of how fish interact with artificial structures in marine environments. These devices effectively attract various fish species seeking food sources or refuge, as they create microhabitats where smaller organisms settle and attract larger predatory fish. This natural attraction behavior suggests that fish might similarly be drawn to other deployed devices such as non-explosive mine assemblies or monitoring equipment. Fish possess sophisticated sensory mechanisms that enable them to navigate their environment and avoid collisions with stationary objects. The lateral line system enables fish to identify and avoid fixed

objects in their path, significantly reducing the likelihood of accidental collisions with deployed devices. This natural avoidance capability is particularly relevant when considering the potential risks associated with anchored or tethered objects in the water column. Aircraft- and vessel-deployed mine shapes, anchor blocks, anchors, 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.

The analysis of potential strike risks from seafloor devices reveals that while fish may be attracted to these structures, their natural sensory capabilities and avoidance behaviors effectively minimize the risk of harmful interactions. The use of seafloor devices in inshore waters would be temporary (days to weeks) and the amount of soft bottom habitat impacted during that short timeframe would be negligible compared to the remaining amount of habitat that would be unaffected by the activities. These findings support the conclusion that deployed seafloor devices pose a discountable strike risk to ESA-listed fish, negating the need for extensive additional protective measures beyond standard operational protocols.

Given the slow movement of seafloor devices, the effort expended by fish to avoid them will be minimal, and behavioral impacts will be temporary, and insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Thus, we conclude that the effects of seafloor devices resulting from the proposed action may affect, but are not likely to adversely affect the following species: Atlantic sturgeon DPSs, shortnose sturgeon, Gulf sturgeon, Nassau grouper, smalltooth sawfish, Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks Central and Southwest Atlantic DPS, and giant manta rays.

Invertebrates

The placement of seafloor devices on the seafloor within areas of habitat used by marine invertebrates may affect the abundance of various benthic species (e.g., amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or crustaceans) that make up the prey resource for queen conch.

Seafloor devices may be set on soft substrate areas in shallow water that may be occupied by queen conch, except within the Florida Key National Marine Sanctuary per agreements with the Office of National Marine Sanctuaries. Considering the sanctuary covers nearly all of the shallow water habitat in the KWRC, the potential for seafloor devices impacting queen conch in that location is discountable. Seafloor devices may be used in Demolition Key (an inshore location of the KWRC) and the SFOMF. In Demolition Key, seafloor devices may be placed on shallow and highly disturbed habitats mostly devoid of seagrass beds and other structured habitats. The vast majority of substrate in the SFOMF to 90 m depths is mapped as shallow-water coral reef where mitigation measures should protect ESA-listed coral species and queen conch from direct impacts from seafloor devices. Disturbance of soft substrate by seafloor devices may cause temporary and localized episodes in turbidity, but the impact on ESA-listed invertebrates nearby would likely be insignificant. Thus, the effects of seafloor devices may

affect, but are not likely to adversely affect, boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, staghorn coral and queen conch.

Entanglement Stressors

Some expended materials from the proposed military readiness activities may pose a risk of entanglement to ESA-listed species in the action area. These interactions could occur at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with military expended materials have the potential to result in non-lethal adverse effects, mortality, or result in no impact. Expended materials that may pose an entanglement risk include guidance wires, fiber optic cables, sonobuoy wires, expendable bathythermograph wires, biodegradable polymers, and decelerators/parachutes. Additional discussion of entanglement stressors is included in Section 2.4.5.

Marine Mammals

There has never been a reported or recorded instance of a marine mammal entangled in military expended materials. NOAA (2014a) conducted a review of entanglement of marine species in marine debris with an emphasis on species in the United States. The review did not document any known instances where military expended material had entangled a cetacean. Instead, the vast majority of entanglements have been from actively fished or derelict fishing gear. For example, Knowlton et al. (2012), as cited in NOAA (2014a), conducted a 30-year comprehensive review of entanglement rates of North Atlantic right whales using photographs. In the report, 626 individuals were observed and the vast majority showed evidence of entanglement involving non-mobile pot gear and nets used for fishing. Military expended material has not been shown to entangle ESA-listed large whales despite the Navy expending materials in the action area (and other range complexes) for decades.

If encountered, it is unlikely that an animal would get entangled in a fiber optic cable, sonobuoy wires, or guidewire while these were sinking or settling on the seafloor. An animal would have to swim through loops or become twisted within the cable or wire to become entangled, and given the properties of the expended cables and wires (low breaking strength and sinking rates) (Navy 2024c) the likelihood of entanglement from cables and wires is extremely low. Additionally, as noted above, though there are numerous documented cases where marine mammals have been entangled in anthropogenic materials (e.g., fishing gear), there have been no documented instances where a marine mammal has been entangled in military expended cables and wires despite decades of training and testing activities being conducted in the action area and elsewhere utilizing wires and cable. For these reasons, the likelihood that an ESA-listed marine mammal will become entangled in military expended wires and cables in the action area is so low as to be discountable.

Biodegradable polymers only retain their strength for a relatively short period of time (Navy 2024c) and are extremely unlikely to pose a potential entanglement risk to marine mammals (see

Section 2.4.5). Additionally, due to the wide dispersion and low numbers of biodegradable polymers, coupled with the patchy distribution of ESA-listed marine mammals in the action area where these materials are dispersed, there is a very low likelihood of ESA-listed marine mammals interacting with biodegradable polymers while they still pose an entanglement risk (i.e., before they biodegrade). In summary, we find that the probability of exposure to effects of entanglement in biodegradable polymers is extremely unlikely, and thus discountable for marine mammals.

Decelerators/parachutes also may pose a risk of entanglement, though for the reasons described below, we do not believe such incidences are likely to occur. The Action Proponents use a variety of sizes of decelerators/parachutes in the action area (see Section 2.4.5 for details). The risk of marine mammal entanglement in small and medium decelerators/parachutes, which make up the majority of parachutes, is extremely low because these items are weighted and remain in the water column for just a few minutes before sinking to the seafloor. It is also possible that sperm whale could become entangled when foraging in areas where parachutes have settled on the seafloor. For example, if bottom currents are present, the canopy may temporarily billow and pose a greater entanglement threat. However, the likelihood of bottom currents causing a billowing of a parachute, a relatively rare ESA-listed marine mammal encountering this billowing parachute, and the animal not detecting and avoiding the entanglement risk is so unlikely as to be considered discountable. Therefore, it is extremely unlikely that an ESA-listed marine mammal would encounter and become entangled in decelerators/parachutes on the seafloor.

The main potential for entanglement is with the large and extra-large decelerators/parachutes. While the large parachutes would eventually sink and flatten, there is the potential that these decelerators/parachutes, which do not have weights attached, could remain suspended in the water column or billow at the seafloor for a longer period of time before flattening (Navy 2024c). The length of the decelerator/parachute lines poses an entanglement risk as well. Up to 80 extra-large parachutes will be used annually for testing, and up to 500 large parachutes will be used annually for testing and training. The majority of these (i.e., up to 44 extra-large and 318 large) will be deployed in the VACAPES RC, with the remainder distributed throughout multiple range complexes within the action area. The Action Proponents will attempt to retrieve large and extra-large parachutes on the surface, however they are not always successful due to logistics and safety concerns. There are a number of key differences between parachutes/decelerators and fishing gear that result in the likelihood of entanglement in parachutes/decelerators being significantly lower than it is for fishing gear. First, as noted above, most decelerators/parachutes proposed for use will sink quickly to seafloor and will not remain suspended in the water column for extended periods of time. This is in contrast to fishing gear which can be left in the water for days or weeks at a time. Additionally decelerators/parachutes would be highly visible in the water column likely alerting a nearby animal to the presence of the obstacle (Figure 5), whereas fishing gear may consist of some buoys and traps that are visible, but also many hundreds of feet

of rope in between these items that is not. Given the anticipated small number of large and extra-large parachutes/decelerators that will be left floating (i.e., not retrieved) in the action area, the low densities of ESA-listed marine mammals in the action area where decelerators/parachutes would be deployed, and their ability to avoid such items, we find it extremely unlikely that an ESA-listed marine mammal would encounter and become entangled in decelerators/parachutes in the open ocean.

For the reasons described above, we consider it extremely unlikely for any marine mammals to become entangled in military expended materials including wires and cables, biodegradable polymers, and decelerators/parachutes. Therefore, potential effects on ESA-listed marine mammals from entanglement in military expended materials are discountable. Thus, we conclude that the effects of entanglement in military expended materials resulting from the proposed action may affect, but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.



Figure 5. Aerial Target with Deployed Parachute (Navy 2017)

Sea Turtles

All of the ESA-listed sea turtles present within the action area could encounter materials that have the potential to entangle them such as wires and cables, decelerators and parachutes, and

biodegradable polymers that are used during AFTT activities. Sea turtles could encounter these items at the water's surface, in the water column, or along the seafloor. Many factors may influence the degree of entanglement risk for sea turtles such as life stage and size, sensory capabilities, and foraging methods (i.e. along the seafloor or in the water column). Similar to other marine animals, most entanglements associated with sea turtles are from fishing gear (as opposed to military items) that float or are suspended at the ocean's surface for long periods of time.

As discussed above for marine mammals, the likelihood of sea turtle entanglement in cables and wires as a result of the proposed action is extremely low given the properties of these expended materials (i.e., low breaking strength and relatively high sinking rates) (Navy 2024c). There have been no documented instances where a sea turtle has been entangled in military expended cables and wires despite decades of training and testing activities being conducted in the action area and elsewhere utilizing wires and cable. Given the low concentration of expended wires and cables, the rapid sink rates, the tensile strength and breakability of the material, and likely distribution of sea turtles in the action area that may co-occur with areas where cables and wires are expended, we consider it extremely unlikely for any sea turtles to be exposed to entanglement in cables and wires as part of the proposed action. For these reasons, the potential impacts from these stressors on sea turtles are discountable.

ESA-listed sea turtles may overlap spatially with expended decelerators and parachutes from training activities in the Northeast, VACAPES, Navy Cherry Point, Jacksonville, Gulf, and Key West Range Complexes, as well as other portions of the action area (Navy 2024c). While in the water column, a sea turtle is not likely to become entangled in these materials because the parachute would have to land directly on the turtle, or the turtle would have to swim into the parachute and its lines, before it sank. Should this unlikely event occur, a sea turtle could likely free itself and swim away from the sinking object.

Sea turtles at or near the water's surface are more likely to encounter and become entangled by floating decelerators, parachutes and cords than those animals located deeper in the water column or foraging along the seafloor. Small and medium decelerators and parachutes are not expected to remain at the water's surface for long, and would begin to sink within five to 15 seconds. While a decelerator and parachute is sinking, it could be carried along within a current, or become snagged on a hard structure near the substrate.

Once these smaller chutes reach the substrate, they will likely flatten and not "billow" from the bottom. If the parachute and associated lines sink to the seafloor in an area that is calm along the substrate, it would likely settle there and remain undisturbed. In an area with bottom currents or active tidal influence, the parachute may move along the seafloor, away from the location in which it was expended. But over time, it may become covered by sediment in most areas or colonized by attaching and encrusting organisms, which would further stabilize the material and reduce the potential for reintroduction as an entanglement risk. Any decelerators or parachutes

that do settle have some small degree of risk to become resuspended, however it is more likely that these items would become buried in sediments as ocean currents move sediment around along the seafloor, or organisms colonize them.

The sink rates of small and medium decelerator and parachute assemblies would rule out the possibility of these drifting great distances into nearshore and coastal areas where benthic foraging species of sea turtles are more likely to occur. Given the sparse distribution of the small and medium decelerators and parachutes deployed and expended throughout the action area, as well as the patchy distribution and general behavior of sea turtles, the likelihood of a sea turtle entanglement in a small or medium sized decelerator or parachute is extremely low (i.e., discountable).

The likelihood for entanglement is higher for the large and extra-large decelerators and parachutes due to their size and length of the attachment cords, and because some of the large and extra-large decelerators and parachutes have the potential to be expended or drift into nearshore habitats, which have a higher concentration of sea turtles. Additionally, these sized parachutes and decelerators are not weighted with anything to help them sink rapidly, thus could potentially remain suspended in the water column for an extended period of time, increasing the chance of sea turtles encountering them in the water column. However, significantly fewer large and extra-large decelerators and parachutes are expended annually during Action Proponent activities, and some of these would be recovered. The chance of a sea turtle encountering one of these expended materials is extremely low given sea turtle distributions and densities throughout the areas where large and extra-large decelerators and parachutes would be used. In addition, there are no known instances of sea turtle entanglement with a Navy or Coast Guard decelerator or parachute assembly in the action area despite decades of military readiness activities using these items. Therefore, the likelihood of a sea turtle entanglement in large or extra-large decelerators or parachutes is discountable.

As discussed above for marine mammals, biodegradable polymers only retain their strength for a relatively short period of time and are extremely unlikely to pose a potential entanglement risk to highly mobile marine species. Exposure of ESA-listed sea turtle species to entanglement in biodegradable polymers is extremely unlikely due to the low level of activity and concentration of these items throughout the action area, sea turtle distributions and densities in areas where polymers would primarily be used, and the short duration that they would pose an entanglement risk due to the physical properties of biodegradable polymers. Therefore, we find that the probability of exposure to effects of entanglement in biodegradable polymers is extremely unlikely and thus discountable for ESA-listed sea turtles.

For the reasons described above, we consider it extremely unlikely for a sea turtle to become entangled in military expended materials including wires and cables, biodegradable polymers, and decelerators/parachutes. Therefore, potential effects on ESA-listed sea turtles from entanglement in military expended materials are discountable. Thus, we conclude that the effects of entanglement in military expended materials resulting from the proposed action may affect,

but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles.

Fish

The susceptibility of ESA-listed fish species to entanglement is governed by a complex interaction of environmental conditions and biological characteristics. Abandoned fishing gear, particularly nets and lines that form loops or incorporate rings, represents the primary source of entanglement hazards in marine environments. These hazardous materials concentrate predominantly in coastal waters and continental shelf regions, where elevated levels of human activity, including commercial fishing operations, coincide with areas of high fish abundance and biodiversity (Browne et al. 2015; Gall and Thompson 2015; Kühn et al. 2015; Compa et al. 2022). The vertical distribution of entanglement risks shows a distinct pattern, with most incidents occurring at or near the surface and within the water column, while fewer cases involve materials settled on the seafloor.

Certain fish species exhibit morphological characteristics that significantly increase their vulnerability to entanglement. Sawfishes, with their distinctive tooth-lined rostrum, are particularly susceptible to entanglement in linear materials such as fishing lines and cables. Similarly, elasmobranchs such as hammerhead sharks with their distinctive head morphology and manta rays with their prominent cephalic fins face elevated entanglement risks compared to species with more streamlined body forms. Sturgeon species, characterized by their protective rows of bony scutes, also demonstrate increased susceptibility to entanglement due to these anatomical features.

Filter-feeding species, particularly manta rays, face unique risks from sonobuoy components due to their feeding behavior and movement patterns through the water column. These species regularly traverse the depths where sonobuoy wires and other components are suspended. The potential for interaction is heightened by the manta rays' characteristic swimming behavior and their inability to swim backwards when confronted with linear obstacles (Miller 2017). This limitation becomes particularly relevant when considering their potential encounters with the vertical wire arrays of deployed sonobuoys.

Biodegradable Polymers

Exposure of ESA-listed fish species to entanglement in biodegradable polymers is extremely unlikely due to the low level of activity and concentration of these items throughout the action area, ESA listed fish distributions and densities in areas where polymers would primarily be used, and the short duration that they would pose an entanglement risk due to the physical properties of biodegradable polymers. 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, 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 soon 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. Biodegradable polymers only retain their strength for a relatively short period of time and are extremely unlikely to pose a potential entanglement risk to highly mobile marine species. Therefore, we find that the probability of exposure to effects of entanglement in biodegradable polymers is so low as to be discountable for ESA-listed fish. We conclude that the effects from entanglement in biodegradable polymers from the proposed action may affect, but are not likely to adversely affect, the following ESA-listed fish species: Atlantic sturgeon DPSs, shortnose sturgeon, Gulf sturgeon, Nassau grouper, smalltooth sawfish, Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks Central and Southwest Atlantic DPS, and giant manta rays.

Wires and Cables

Guidance wires, fiber optic cables, sonobuoy wires, and expendable bathythermograph wires are used during training and testing activities. Given the scarcity of Atlantic salmon, and the low density of wires and cables expended in Northeast Range Complexes, the likelihood of an encounter would be extremely low. If an Atlantic salmon was to encounter an expended wire, its size and body type do not lend itself to entanglement, therefore, entanglement for Atlantic salmon is discountable. Based on the analysis of potential interactions between Atlantic sturgeon and military training and testing equipment, the risk of adverse impacts from entanglement also appears minimal. The limited quantity of materials deployed in areas where Atlantic sturgeon occur, and the sturgeon's physical capabilities support this conclusion. While the species' distinctive morphological features might theoretically increase susceptibility to entanglement, their size and strength would likely enable them to avoid or escape such situations. Therefore, while the potential for encounters exists, the risk of entanglement impacts on Atlantic sturgeon populations is discountable (i.e., extremely unlikely). Shortnose sturgeon exhibit distinct habitat preferences that largely confine them to river systems and nearshore waters along the eastern seaboard. Unlike their Atlantic sturgeon cousins, shortnose sturgeon demonstrate a strong predilection for riverine environments, typically remaining within their natal river systems and adjacent estuaries. When these fish do venture into marine waters, they generally stay close to shore, making only brief excursions into coastal areas before returning to their river habitats. This behavioral pattern significantly limits their potential exposure to military training and testing activities, as most of these operations occur in offshore waters beyond their typical range. The spatial distribution of AFTT activities is particularly relevant when considering potential interactions with shortnose sturgeon. Given that these operations typically occur in offshore waters, while shortnose sturgeon prefer riverine and nearshore habitats, the likelihood of encounters between this species and expended wires and cables is extremely low. While their distinctive morphological features, particularly their scutes, might theoretically increase their susceptibility to entanglement, the spatial separation between their preferred habitat and the location of military activities, combined with their significant physical strength, effectively minimizes the likelihood of adverse interactions. Therefore, while the potential for encounters exists, the risk of entanglement impacts on shortnose sturgeon populations is discountable.

Gulf sturgeon inhabit a distinct range within the northern Gulf of America, including rivers, bays, and estuaries from Louisiana to Florida. Their critical habitat encompasses fourteen geographic areas among Gulf of America rivers and tributaries, representing essential spawning, feeding, and migratory environments. Military training and testing activities involving wires and cables primarily occur within the Gulf Range Complex and the Naval Surface Warfare Center Panama City Testing Range. The U.S. Air Force Eglin Gulf Test and Training Range, that coincides with the Navy range complex and is a significant component of these operations, intersects with areas where Gulf sturgeon are known to occur. While there is some geographic overlap between military activities and Gulf sturgeon habitat, the majority of training and testing operations involving cables and wires take place in offshore waters, beyond the species' primary foraging grounds. The comprehensive analysis of potential interactions between Gulf sturgeon and military training equipment suggests minimal risk of adverse impacts from entanglement. This conclusion is supported by several key factors: the limited quantity of cables and wires deployed, the sturgeon's physical capability to break free from potential entanglements, and the predominant deployment of materials outside the Gulf sturgeon's primary habitat areas. While the species' distinctive morphological features might theoretically increase their susceptibility to entanglement, the spatial separation between primary military activities and Gulf sturgeon habitat, combined with their significant physical strength, effectively minimizes the likelihood of adverse interactions. Therefore, while the potential for encounters exists, the risk of entanglement impacts on Gulf sturgeon is discountable. The proposed action activities involving the use of wires and cables primarily occurs outside of the typical distribution and habitat use of smalltooth sawfish. Although it is possible that some sawfish may occur in the continental shelf waters of the Jacksonville, Key West, and Gulf Range Complex and two testing locations (South Florida Ocean Measurement Facility and the Naval Surface Warfare Center Panama City Testing Range), this would be a rare occurrence. While smalltooth sawfish may be more susceptible to entanglement than most other species due to the unique saw-like morphology of their snout, their rare occurrence in areas where cables and wires would be in use render the likelihood of an encounter so remote as to be discountable. The activities associated with wires and cables occur mostly seaward of the coastal zone. Therefore, while the potential for encounters exists, the risk of entanglement impacts on smalltooth sawfish is discountable.

In summary, the effects of entanglement stressors associated with guidance wires, fiber optic cables, sonobuoy wires, and expendable bathythermograph wires from the proposed action may affect, but are not likely to adversely affect, the following ESA-listed fish species: Atlantic sturgeon DPSs, shortnose sturgeon, Gulf sturgeon, Nassau grouper, smalltooth sawfish, Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks Central and Southwest Atlantic DPS, and giant manta rays.

Parachutes and Decelerators

Parachutes and decelerators could potentially be encountered by ESA-listed fish at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of

marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses if a fish encounters them. Several environmental factors contribute to the reduced likelihood of ESA-listed fish entanglement with military expended materials, including parachutes and decelerators. Current patterns and water movement tend to disperse materials over wide areas, significantly reducing the density of potential entanglement hazards. Additionally, many materials settle relatively quickly to the seafloor, where they become partially or fully buried in sediment, further reducing their potential to cause entanglement. The design characteristics of military expended materials incorporate features that inherently reduce entanglement risk. Parachutes and decelerators used in military operations are constructed with materials that tend to compress and collapse upon water impact. This behavior, combined with the weight of attached components, promotes rapid sinking and reduces the time during which materials remain suspended in the water column where interaction with marine species might occur. The behavioral and morphological characteristics of most ESA-listed fish species, such as streamlined body shape (e.g., Atlantic salmon, sharks), or robust body shape and protective scutes (e.g., sturgeon), provide natural defenses against entanglement. Furthermore, the tendency of sturgeon to remain in deeper channels and structured swimming patterns reduce the likelihood of interaction with suspended materials in the water column.

Of the ESA-listed species in the action area, giant manta rays are likely to be the most susceptible to entanglement in parachutes and decelerators. A study in Hawaii found 10% of manta rays (28 individuals out of a sample of 290) had cephalic fins (fins on either side of the mouth) amputated, disfigured, or were non-functioning (Deakos et al. 2011), apparently due to entanglement in monofilament fishing line. Other evidence has documented mortality of manta rays from entanglement with anchor and mooring lines (Bigalow and Schroeder 1953, Deakos et al. 2011). Manta ray susceptibility to entanglement is largely due to their unique body shape, particularly their cephalic fins.

Giant manta rays have the potential to be present anywhere in the action area within the Gulf of America and along the Atlantic coast as far north as New Jersey, including areas where AFTT activities involving the use of decelerators and parachutes occur. Manta ray susceptibility to entanglement is largely due to their unique body shape, particularly their cephalic fins. However, manta rays are highly mobile species that are expected to be able to avoid the small or medium-sized floating or suspended decelerators and parachutes, which comprise the majority of the decelerators and parachutes used in the action areas. Furthermore, since the small and medium decelerators and parachutes have weights attached they will sink at a more rapid rate (compared to larger unweighted decelerators and parachutes), thereby decreasing the amount of time materials float at the surface, reducing the risk of an ESA-listed fish encountering them.

The large and extra-large decelerators and parachutes may pose a higher degree of entanglement risk because these parachutes are larger and have long lines (large chutes have 28 cords, approximately 40 to 70 ft long; extra-large parachutes have 64 cords, up to 82 ft long), associated

with them. Additionally, large parachutes are not weighted with anything to help them sink rapidly, and could potentially remain suspended in the water column for an extended period of time. However, the chance of an encounter is remote given the small number of the large or extra-large parachutes proposed to be deployed and the anticipated low abundance of ESA-listed species, in general, in the action area. Given the vast area over which any one of these large decelerators and parachutes would be deployed and the limited number of them deployed annually, the chances of a giant manta ray (or any other ESA-listed fish) encountering them and becoming entangled is extremely low. During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practical consistent with personnel and equipment safety. This standard operating procedure could further reduce the potential entanglement of ESA-listed fish in decelerators/parachutes.

Additionally, available data indicates the entanglements and injuries described for this species are mostly due to exposure to fishing gear such as monofilament lines and large heavy mooring lines. The materials of parachutes and decelerators and lines are not the same, and are considered lighter and more likely to sink over some period of time and ultimately settle on the seafloor. Monofilament lines are hard to see for fish and can float indefinitely in the water column unless they become attached to something that anchors them or causes them to sink. They also can easily form multiple loops. Mooring lines are quite heavy and likely more difficult for animal to release itself from should it become ensnared in a mooring line. Furthermore, no cases of fish entanglement have been reported for parachutes or decelerators (U.S. Department of the Navy 2001; Ocean Conservancy 2010). While we recognize that there is a higher risk of entanglement for giant manta rays than for other fish species, similar to other species, giant manta rays are likely able to visually detect and avoid descending or sinking parachutes in the water column. This is expected to result in a minor behavioral response.

In summary, due to the factors discussed above, we find it extremely unlikely (i.e., discountable) that ESA-listed fish will become entangled in parachutes or decelerators as a result of the proposed action, and the effects of any behavioral response by ESA-listed fish to avoid parachutes or decelerators in the water column will be insignificant. Thus, we conclude that the effects of entanglement from parachutes and decelerators used during the proposed action may affect, but is not likely to adversely affect, the following ESA-listed fish species: Atlantic sturgeon DPSs, shortnose sturgeon, Gulf sturgeon, Nassau grouper, smalltooth sawfish, Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks Central and Southwest Atlantic DPS, and giant manta rays.

Invertebrates

Under the proposed action, fiber optic cables, guidance wires, sonobuoy wires, decelerators/parachutes, biodegradable polymers and bathythermograph wires would be expended in the KWRC and SFOMF. The vast majority of expended wires/cables would be sonobuoy wires used for testing in the KWRC. However, the associated activities would take

place mostly seaward of queen conch habitat and the materials are unlikely to drift to shallower waters due to the prevailing oceanic currents (e.g., Loop Current, Florida Current).

It is unlikely that a queen conch would become entangled in wires or cables. The items would be essentially linear and untethered 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. 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 mostly offshore in the KWRC and SFOMF would result in an extremely low (i.e., discountable) rate of potential encounter for ESA-listed queen conch. Thus, the effects of entanglement stressors associated with the proposed action may affect, but are not likely to adversely affect, queen conch.

As sessile organisms, we find no pathway to effects from entanglement of ESA-listed coral colonies from military expended materials as part of the proposed action. Although mobile, coral larvae are too small to become entanglement in AFTT military expended materials.

Ingestion Stressors

This section analyzes the potential impacts of ingestion stressors resulting from military readiness activities in the action area. This analysis includes the potential impacts from the following types of military expended materials: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), decelerators/parachutes, and biodegradable polymers. Military readiness activities throughout the action area result in expended materials that could potentially be ingested. These expended materials are typically widely distributed and low in density, given the size of the action area and number of locations where such activities occur. The majority of material expended during training and testing activities would likely become naturally buried in sediments or penetrate the seafloor and not be accessible to most marine species that feed in the water column. Species that feed on benthic prey (e.g., sturgeon) could still be susceptible to ingestion of military expended materials after they sink to the seafloor. Additional discussion of ingestion stressors is included in Section 2.4.6.

Marine Mammals

Most expendable materials would be used over deep water portions of the action area and most items are expected to sink quickly and settle onto the seafloor, with the exception of chaff and some firing target materials. Given the limited time most items will spend in the water column, it is not likely that these items would be accidentally ingested by ESA-listed marine mammals that do not typically forage on the sea floor. Of the marine mammals in the action area, the only species potentially exposed to expended munitions and shrapnel fragments while foraging on the sea floor in deep water is sperm whales. However, the relatively low density of both sperm whales and expended materials along the vast sea floor suggests ingestion of such items would

be extremely unlikely. If a large whale were to accidentally ingest expended materials small enough to be eaten, it is likely the item will pass through the digestive tract and neither result in an injury (e.g., Wells et al. 2008) nor an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering.

ESA-listed marine mammals may also encounter military expended material that remains suspended in the water column for extended periods of time. Because baleen whales feed by filtering large amounts of water, they could encounter and consume debris at higher rates than other marine animals (NOAA 2014a). For example, baleen whales are believed to routinely encounter microplastics (from numerous anthropogenic sources) within the marine environment based on concentrations of these items and baleen whale feeding behaviors (Andrady 2011). Laist (1997) reported on two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag. Bergmann et al. (2015) documented records of marine debris ingestion in seven mysticetes, including right whales, pygmy right whales, gray whales, and four rorqual species. Information compiled by Williams et al. (2011) listed humpback whale, fin whale, and minke whale as three species of mysticetes known to have ingested debris including items the authors characterized as fishing gear, polyethylene bag, plastic sheeting, plastic bags, rope, and general debris. Military expended materials were not documented as having been consumed in any of these studies.

Some Styrofoam, plastic endcaps, and other small military expended materials (e.g., chaff, flare pads, pistons) may float for some time before sinking. However, these items are likely too small to pose a risk of intestinal blockage to any cetacean that happened to encounter and accidentally swallow the item. Chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to its light weight and small size this floating material can be carried great distances in both air and water currents. Their dispersal in wind and water results in chaff fibers likely occurring in low densities on the ocean surface. Several literature reviews and controlled experiments have indicated that chaff poses little risk, except at concentrations substantially higher than those that could reasonably occur from military readiness activities (Force 1997; Hullar et al. 1999; Arfsten et al. 2002). Similar to chaff, flare pads and pistons are also relatively small and float in sea water. Given the small size, low densities, and low toxicity of chaff or flare expended materials, any accidental ingestion by ESA-listed marine mammals feeding at the ocean surface is not expected to result in an injury or an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering. Chaff cartridge plastic end caps and pistons and flare pads would also be released into the marine environment during military readiness activities, where they may persist for long periods, and therefore could be ingested by marine mammals while initially floating on the surface and sinking through the water column. However, these materials would eventually sink to the seafloor where they would be less likely to be ingested by marine mammals. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur.

In conclusion, because we expect smaller military expended materials would likely pass through marine mammals with no adverse effects, the effects of ingestion of small expended materials are insignificant. Since ingestion of military expended material of sufficient size to result in adverse effects to ESA-listed marine mammals is extremely unlikely, the effects of ingestion of large expended materials are discountable. While baleen whales could accidentally ingest chaff or flare remains, if this occurs the effects of these stressors on those individuals exposed are expected to be so minor as to be insignificant. Therefore, we conclude the effects of ingestion of expended materials from activities associated with the proposed action may affect, but are not likely to adversely affect the following species: blue whale, fin whale, North Atlantic right whale, sei whale, Rice's whale, and sperm whale.

Sea Turtles

The munitions and other materials small enough to be ingested by ESA-listed sea turtles are small and medium caliber projectiles (up to 2.25 in), broken pieces of firing targets, chaff, flare casings (caps and pistons), decelerators and parachutes (cloth, nylon and metal weights) and shrapnel fragments from high-explosives ordnance. Most expendable materials will be used over deep water and these items will sink quickly and settle on the seafloor, with the exception of chaff and some firing target materials.

Navy training activities involving non-explosive practice munitions in the inshore waters occur in several locations along the Atlantic coast, but fewer munitions are anticipated to be expended on an annual basis in these inshore areas compared to activities located in offshore areas. Therefore, most of the expended munitions would occur in deeper waters. The highest concentration of munitions in in-shore waters would be in the James River and Tributaries. Other in-shore locations include the Lower Chesapeake Bay, Port Canaveral, Florida, and Narragansett Bay, Rhode Island. In inshore waters, training activities would concentrate small-caliber shell casings in areas that may potentially be over benthic foraging areas (e.g., Lower Chesapeake Bay and Port Canaveral). Life stages of sea turtles potentially affected in these areas would be juvenile, sub-adult, and adult green, loggerhead, Kemp's ridley, and hawksbill sea turtles. These species are more likely to encounter munitions of ingestible size that settle on the substrate. Because leatherback sub-adult and adult sea turtles forage in coastal surface waters, they would be less likely to ingest expended materials.

Types of munitions that can result in fragments include demolition charges, projectiles, missiles, and bombs. The size of these fragments would vary depending on the NEW, size, and munitions type. Fragments that could be encountered by sea turtles would most likely be those that have settled on the seafloor. Other munitions and munitions fragments such as large-caliber projectiles or intact training and testing bombs are too large for sea turtles to consume and are made of metal a sea turtle would not be able to break apart and ingest. Chaff fibers are too small for sea turtles to confuse with prey and forage, but there is the possibility that sea turtles could come in contact or accidentally ingest some of the material. If this occurs, chaff is not expected to impact

sea turtles due to the low concentration that would be ingested and the small size of the fibers. Chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to their light weight and small size they float and can be carried great distances in both air and water currents. Their dispersal in wind and water results in chaff fibers likely occurring in low densities on the ocean surface. Given the small size, low densities, and low toxicity of chaff, any accidental ingestion by ESA-listed sea turtles feeding at the ocean surface is not expected to result in an injury or an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur.

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, during AFTT activities, where they may persist for long periods and therefore could be ingested by sea turtles while initially floating on the surface and sinking through the water column. However, these end caps would eventually sink to the seafloor where they would be less likely to be ingested by some life stages or species of sea turtles, such as hatchlings and pre-recruitment juveniles of all sea turtle species and all life stages age of leatherback sea turtles. As mentioned above, green, hawksbill, Kemp's ridley, and loggerhead sea turtles could have a higher potential to ingest these items if they settle in potential benthic feeding habitat.

Should a sea turtle encounter military expended materials, it is unlikely that it would ingest every fragment it encounters. Sea turtles may attempt to ingest a projectile and then reject it after realizing it is not a food item. Additionally, ingestion of items would not necessarily result in injury or mortality to the individual if the item does not become embedded in tissue (e.g., Wells et al. 2008). It is likely that most ingested material would pass through the digestive tract of the animal. We are unaware of any data indicating military items have been found in sea turtles that have been necropsied, unlike plastics that appear similar to jellyfish or other prey to a sea turtle (Schuyler et al. 2016). Plastic bags are the most commonly ingested type of debris amongst sea turtles (NOAA 2014b). If material is ingested, ingestible-sized items would likely be spit out or passed through the digestive tract without significantly impacting the individual. In addition, given the limited geographic area where materials other than munitions are expended during a given event, and the short duration of time these military expended materials would remain in the water column, the probability of a sea turtle encountering these materials is low.

In summary, ingestion of military expended material of sufficient size to cause an adverse effect by ESA-listed sea turtles is extremely unlikely and is considered discountable. The effects of any accidental ingestion of military expended materials that are small enough to be ingested by ESA-listed sea turtles would be so minor as to be insignificant for the reasons discussed above. We conclude that the effects of ingestion of military expended materials resulting from the proposed action may affect, but are not likely to adversely affect the following species: North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback sea turtles.

Fish

Ingestion of military expended materials by fishes could occur in portions of the action area, 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. 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 (e.g., Atlantic salmon, oceanic whitetip sharks) and open-ocean planktivores (e.g., giant manta rays) may ingest materials in the water column. Coastal and estuarine bottom-dwelling predators (e.g., sturgeon, hammerhead sharks, sawfishes, and Nassau grouper) may ingest materials from the seafloor. The potential for 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 composed of a variety of materials in various sizes. Ingesting nonfood items is common among a variety of marine fishes, particularly those that feed on the seafloor (Hoss and Settle 1990; Jackson et al. 2000; Boerger et al. 2010). 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 and Settle 1990; Jackson et al. 2000). Larger filter feeders such as manta rays could inadvertently ingest a small or medium parachute or decelerator. 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. Relatively small or smooth objects 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 (Hoss and Settle 1990; Danner et al. (2009). Ingestion of large foreign objects could lead to disruption of a fish's normal feeding behavior, which could potentially be sublethal or lethal.

The potential for marine species to ingest military expended materials varies significantly based on their feeding behaviors, habitat preferences, and life history characteristics. Recent studies demonstrate that different marine species exhibit varying levels of vulnerability to munition ingestion based on their ecological niches and behavioral patterns.

Open-ocean species demonstrate distinct patterns of potential exposure to military expended materials. Atlantic salmon, oceanic whitetip sharks, and giant manta rays, which inhabit the pelagic zone, may encounter floating munitions in the water column. However, the risk varies significantly among these species. Giant manta rays, being filter-feeders, are not expected to

deliberately ingest munitions, while Atlantic salmon's presence is restricted to the northern portions of the Northeast Range Complexes, limiting their potential exposure. The rapid sinking nature of military expended materials substantially reduces the window of opportunity for pelagic species to encounter and ingest these items. Recent studies indicate that when pelagic fish do encounter such materials, they typically demonstrate discriminatory feeding behavior, often rejecting non-food items after initial contact.

Coastal and benthic-dwelling species face different exposure scenarios due to their habitat preferences and feeding strategies. Species such as sturgeon, scalloped hammerhead sharks, smalltooth sawfish, and Nassau grouper interact primarily with materials that settle on the seafloor. Nassau grouper, as opportunistic ambush predators, might initially strike at descending munitions, mistaking them for prey. However, their sophisticated sensory capabilities typically enable them to distinguish between actual prey and artificial materials. Recent research demonstrates that bottom-dwelling species exhibit varying degrees of risk based on their specific habitat preferences and feeding behaviors.

Current evidence suggests that different species face varying levels of risk based on their biological characteristics and behavioral patterns. Scalloped hammerhead sharks, equipped with highly developed electroreception, are unlikely to mistake expended munitions for prey. Smalltooth sawfish, primarily inhabiting nearshore habitats in southern Florida, face minimal risk due to their limited overlap with areas where munitions are expended. Studies indicate that early life stages of these species typically occupy very shallow waters, further reducing their exposure to military expended materials.

Atlantic and Gulf sturgeon populations present unique considerations due to their benthic feeding habits and habitat use patterns. These species, occurring from coastal waters to the continental shelf break, may encounter expended materials that have settled to the sea floor during their bottom-feeding activities. This would likely occur in the Northeast, Navy Cherry Point, and JAX Range Complexes particularly in Narragansett, Rhode Island and the Cooper River, South Carolina where activities overlap with known Atlantic and shortnose sturgeon occurrence. In these inshore waters, sturgeon have a greater chance of encountering military expended materials (munitions). The Navy notes that munitions are much more densely aggregated here due to continued activities in small confined areas. Thus, although unlikely, the potential increase in sturgeon numbers in this area and larger concentration of expended munitions, sturgeon ingestion risk is higher. The Navy only uses small-caliber brass casings in these areas that drop into the water while firing blank rounds. The diet of sturgeon is comprised of some prey items that have hard body parts (e.g. shells and carapaces from mollusks and shrimp) so there is a potential for them to mistakenly ingest some of the expended munitions. Therefore, munitions and fragments of munitions on the bottom or within the substrate could possibly be mistaken for a food item or could be incidentally taken along with other food items. An encounter with a casing would not necessarily lead to ingestion or swallowing of the item, as a fish might "taste" the item and then expel it (Felix et al. 1995). However, because they normally are able to pass

small, hard bodied prey, a small caliber casing is unlikely to cause a blockage or other digestive issues as these items are relatively small and smooth and would likely pass through a sturgeon's digestive tract without causing harm. In addition, Lari et al. (2013) demonstrates that while sturgeon might encounter settled materials during feeding, their ability to process hard-bodied prey items suggests minimal risk from ingesting smooth-surfaced materials such as small-caliber projectiles. Juvenile sturgeon face even lower risk due to their habitat preferences, which typically do not overlap with areas where military materials are expended. Therefore, the potential effects of rare cases where Atlantic and shortnose sturgeon may ingest munitions are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated (Lari et al. 2013).

Based on comprehensive analysis of species-specific behaviors, habitat preferences, and documented interactions with anthropogenic materials, the risk of adverse effects from munition ingestion appears minimal for ESA-listed fish species. The combination of rapid sinking rates of materials, species' discriminatory feeding behaviors, and limited spatial overlap between sensitive life stages and expended materials suggests that the likelihood of significant negative impacts is extremely low. For the reasons provided above, we consider it extremely unlikely (i.e., discountable) that ESA-listed fish species would ingest materials resulting in adverse effects to the fish's normal behavior, growth, survival, or reproductive success. Therefore, the effects of ingestion of expended materials resulting from the proposed action may affect, but are not likely to adversely affect the following ESA-listed fish species: Atlantic sturgeon DPSs, shortnose sturgeon, Gulf sturgeon, Nassau grouper, smalltooth sawfish, Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks Central and Southwest Atlantic DPS, and giant manta rays.

Stressors Resulting in Effects to Habitat or Prey of ESA-listed Species

This section analyzes potential impacts to ESA-listed marine mammals, sea turtles, fish, and invertebrates exposed to stressors indirectly through impacts to their habitat or prey. The stressors evaluated in this section include: explosives; explosive byproducts and unexploded munitions; metals; and chemicals. These secondary (or indirect) stressors are analyzed collectively for all taxa because the potential effects to prey and habitat are the same across taxa.

Explosives

Explosives used during AFTT activities could impact other species in the food web, including prey species that marine mammals, sea turtles, fish, and invertebrates feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Hanlon and Messenger 1996; Mather 2004). The abundances of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers

from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected.

Explosive Byproducts and Unexploded Munitions

High-order explosions (i.e., a successful explosion or an explosion that produces the intended result) consume almost all of the explosive material in the ordnance, leaving little to no material in the environment that could affect marine mammal species or their habitats. By contrast, low order detonations and unexploded munitions leave more explosive material in the environment. Lotufo et al. (2010) studied the potential toxicity of Royal Demolition Explosive byproducts to marine organisms. The authors concluded that degradation products of these explosives are not toxic at realistic exposure levels. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6 to 12 inches away from degrading munitions, the concentrations of these compounds were not statistically distinguishable from baseline levels beyond 3 to 6 ft from the degrading munitions. Based on these results, while it is possible that ESA-listed species could be exposed to degrading explosives, such exposure would likely only occur within a very small radius of the explosive, and exposure to degrading explosives at toxic levels is extremely unlikely.

Given the large size of the ocean areas where explosives could be used, the concentration of munitions, explosives, expended material, or devices in any one location within the action area are expected to be relatively small. As a result, explosion by-products and unexploded munitions are not anticipated to have adverse effects (i.e., no measureable effects are anticipated) on water quality or ESA-listed species prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on ESA-listed species through impacts on prey and water quality are considered insignificant. Therefore, we conclude that effects to prey and water quality from explosive byproducts and unexploded munitions associated with the proposed action may affect, but are not likely to adversely affect ESA-listed species.

Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, munitions, and other military expended materials (Environmental Sciences Group, 2005). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Evidence from a number of studies (Navy 2013; Briggs et al. 2016; Edwards et al. 2016; Kelley et al. 2016; Koide et al. 2016) indicate metal contamination is highly localized and that bioaccumulation resulting from munitions cannot be demonstrated. Specifically, in sampled marine life living on or around munitions on the seafloor, metal concentrations could not be definitively linked to the munitions because comparison of metals in sediment next to munitions show relatively little difference in comparison to other baseline marine sediments used as a control (Koide et al. 2016). Research has demonstrated that some smaller marine organisms are attracted to metal munitions as a hard

substrate for colonization or as shelter (Kelley et al. 2016; Smith and Marx Jr. 2016), but this would not have an effect on the availability of marine mammal prey. The research cited above indicates that metals introduced into the action area are unlikely to have measureable impacts on ESA-listed species prey or habitat. Thus, the effects of metals introduced into seawater and sediments on ESA-listed species through impacts to their prey or habitat are insignificant. Therefore, we conclude that the effects to prey and water quality from metals introduced into seawater and sediments as a result of the proposed action may affect, but are not likely to adversely affect ESA-listed species.

Chemicals

Several military readiness activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed species or their prey. Chemicals introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares, missiles, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment. Flares and missiles that operationally fail may release perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals if in sufficient concentration. However, such concentrations would be localized and are not likely to persist in the ocean. Research has demonstrated that perchlorate did not bio concentrate or bioaccumulate, which was consistent with the expectations for a water-soluble compound (Furin et al. 2013). Given the dynamic nature of the environment (currents, tides, etc.), long-term impacts from perchlorate in the environment near the expended item are not expected. It is extremely unlikely that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on ESA-listed species prey or habitat. For these reasons, the effects of chemicals used during the proposed training and testing activities are insignificant. We conclude that the effects of chemicals released into the water column as a result of the proposed action may affect, but are not likely to adversely affect ESA-listed species through impacts to their prey or habitat.

4.1.2 Species Not Likely to be Adversely Affected

Nassau Grouper

NMFS listed the Nassau grouper as threatened under the ESA effective July 29, 2016 (81 FR 42268, June 29, 2016). The Nassau grouper's confirmed distribution currently includes "Bermuda and Florida (USA), throughout the Bahamas and Caribbean Sea" (Hill and Sadovy de Mitcheson 2013). The Nassau grouper is a moderate-sized serranid fish. As with many serranids, the Nassau grouper is slow-growing and long-lived; estimates range up to a maximum of 29 years (Bush et al. 1996). Using length-frequency analysis, which tends to exclude younger animals, a theoretical maximum age at 95% asymptotic size is 16 years. Nassau grouper may occur in the southern portion of the Navy's JAX Range Complex and in the KWRC and Gulf

Range Complexes. They occur in nearshore areas, around coral reefs and within rocky substrates, and may also occur in waters as deep as 100 m.

Based on our effects analysis of the proposed action on Nassau grouper, we estimate that for acoustic stressors resulting from sonar and other transducers and explosives Nassau grouper will not be present, or would only have a very low probability of being adversely affected if they were present, due to the small portions of the action area that they occupy. Although they may be exposed to some of the stressors discussed in this opinion, the magnitude and duration of exposures are expected to be brief, episodic and are not expected to result in any harm or harassment to Nassau grouper. See Section 4.1.1 for a discussion of the AFTT stressors that are not likely to adversely affect any ESA-listed species.

Nassau grouper exhibit a highly specific distribution pattern that intersects with AFTT activities primarily in the KWRC and SFOMF. Their habitat preferences are closely tied to reef structures, showing particular affinity for high-relief coral reefs and rocky outcrops in clear waters (Hill and Sadovy de Mitcheson 2013). This specific habitat requirement naturally restricts their potential exposure to vessel traffic, in general. Their benthic lifestyle, limited geographic distribution within AFTT operation areas, and strong association with reef structures naturally minimize potential encounters with AFTT vessels and USVs. While the species may occasionally respond to the presence of AFTT vessels or USVs with short-term behavioral changes, such as startle responses or diving behavior, these interactions are unlikely to result in physical strikes or negative impacts on individual fitness. The primary risk factors typically associated with vessel strikes - such as frequent surface activity or occurrence in high-traffic areas - are notably absent in Nassau grouper's behavioral repertoire, making adverse encounters with AFTT vessels or USVs a highly improbable occurrence. Therefore potential effects to Nassau grouper from vessel and USV strike is discountable.

Because they have the potential to be present within the action area during Navy training activities that use explosives, Nassau grouper could be exposed to sound and energy from explosives throughout the year. The southern portions of the JAX Range Complex are not the portion of the range complex where explosives are used (i.e., outside of the Jacksonville OPAREA), therefore Nassau grouper are not expected to be exposed to explosives within this area. Within the KWRC, the probability that Nassau grouper would be exposed to explosives would also be extremely low. Nassau grouper may be present on or near coral reefs within these areas, but these areas are protected from exposure due to mitigation measures the Action Proponents will implement to prevent explosives from being discharged on mapped coral reefs (Section 2.3.2). Nassau grouper could occur in the Gulf Range Complex but would be expected to be located in areas around Flower Garden Banks which is a very small portion of the overall range complex. Moreover, the Navy does not propose to conduct any activities using explosives in the Flower Gardens Banks National Marine Sanctuary. Testing activities that are conducted in the KWRC and the Naval Surface Warfare Center, Panama City Division Testing Range may use the explosives categorized into small bin sizes like E5. No ship shock trials are expected to occur

in offshore areas where Nassau grouper could occur. Given that Nassau grouper are not likely to be exposed to injurious sound levels produced during the use of explosives, no injury, mortality or hearing loss is expected. Similarly, if a Nassau grouper were able to detect an acoustic sound source (e.g. hear it) from far away, we do not anticipate any injury to occur, but rather only mild behavioral responses indicating the fish detects an acoustic stimulus. We do not anticipate the potential for fitness consequences of any Nassau grouper to occur from these temporary changes in behavior. Similarly, we do not anticipate any long-term adverse effects on either individual fish or the population resulting from temporary changes in behavior. Therefore, while sonar and other transducers, explosives, and vessel disturbance may cause short-term physiological stress or behavioral reactions for exposed Nassau grouper, these effects are considered insignificant. In addition, we find the effects of vessel strike on this species to be discountable. See Section 4.1.1 for a discussion of the AFTT stressors that are not likely to adversely affect any ESA-listed species. Therefore, since we find that any effects of sonar and other transducers, explosives, and vessel disturbance are insignificant, and the effects of vessel strike are discountable, Nassau grouper is not likely to be adversely affected by the proposed action, and will not be discussed further in this opinion.

Shortnose Sturgeon

Shortnose sturgeon was first listed under the Endangered Species Preservation Act on October 15, 1966 (32 FR 4001). When the ESA was signed into law in 1973, replacing the Endangered Species Preservation Act, shortnose sturgeon remained listed as endangered. Shortnose sturgeon occur along the Atlantic coast of North America from the Saint John River in Canada to the Saint Johns River in Florida. Currently, shortnose sturgeon can be found in 41 bays and rivers along the U.S. East coast, but their distribution across this range is broken up, with a large gap of about 250 miles (400 km) separating the northern and Mid-Atlantic metapopulations from the southern metapopulation (King 2014).

Although they spend their time primarily in river systems, shortnose sturgeon occasionally enter estuarine and coastal marine waters and could potentially encounter sonar and other transducers, explosives, and vessels. Because shortnose sturgeon primarily occur in riverine habitats they are expected to be located outside the limits of most of the action area. For this reason, and their generally low population numbers along most of their range, shortnose sturgeon are extremely unlikely to be exposed to sonar and other transducers, explosives, or vessel strike. While the species may occasionally respond to the presence of AFTT vessels or USVs with short-term behavioral changes, such as startle responses or diving behavior, these interactions are unlikely to result in physical strikes or negative impacts on individual fitness.

Therefore, since we find that any effects of sonar and other transducers, explosives, and vessel strike for shortnose sturgeon to be discountable, and effects of vessel disturbance to be insignificant, this species is not likely to be adversely affected by the proposed action, and will not be discussed further in this opinion. See Section 4.1.1 for a discussion of the AFTT stressors that are not likely to adversely affect any ESA-listed species.

4.1.3 Critical Habitat Not Likely to be Adversely Affected

North Atlantic Right Whale Designated Critical Habitat

Critical habitat was designated for the North Atlantic right whale in 1994 and expanded in 2016. North Atlantic right whale critical habitat includes two major units, both of which occur within the action area: Unit 1 located in the Gulf of Maine and Georges Bank Region and Unit 2 located off the coasts of North Carolina, South Carolina, Georgia, and Florida (Figure 6).

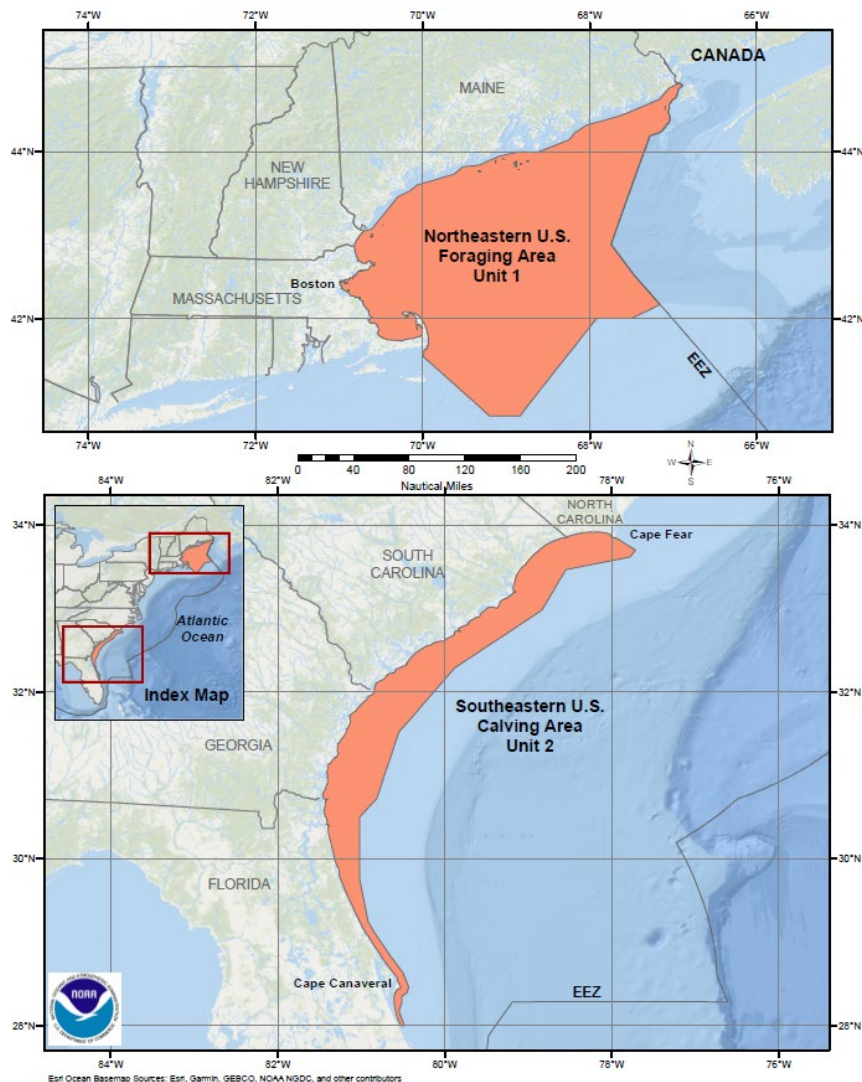


Figure 6. North Atlantic Right Whale Critical Habitat

Unit 1 consists of important foraging areas and contains the following PBFs essential to the conservation of the species:

- Physical oceanographic conditions and structures of the Gulf of Maine and Georges Bank region that combine to distribute and aggregate the zooplankton species *C. finmarchicus* for right whale foraging, namely prevailing currents and circulation

- patterns, bathymetric features (basins, banks, and channels), oceanic fronts, density gradients, and temperature regimes;
- Low flow velocities in Jordan, Wilkinson, and Georges Basins that allow diapausing *C. finmarchicus* to aggregate passively below the convective layer so that the copepods are retained in the basins;
- Late stage *C. finmarchicus* in dense aggregations in the Gulf of Maine and Georges Bank region; and
- Diapausing *C. finmarchicus* in aggregations in the Gulf of Maine and Georges Bank region.

Proposed AFTT military readiness activities directly overlap with some of the essential features of the Northeastern U.S. Foraging Area (Unit 1) of North Atlantic right whale critical habitat. None of the stressors (Section 2.4) associated with the proposed activities would significantly alter the physical or oceanographic conditions, structures or flow velocities within the action area, and no changes in ocean bathymetry would occur. *C. finmarchicus* would either not respond to the non-impulsive acoustic stressors described in Section 2.4.1 (i.e., vessel and aircraft noise, sonar, and weapons noise) or respond in a way that any effects would be considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Noise from explosives is similar to that produced by seismic air guns in that it is characterized by rapid pressure changes, as well as loud, impulsive, broadband sounds (Hildebrand 2009a). Recent evidence from McCauley et al. (2017) indicates that impulsive sounds such as seismic air guns may lead to a significant reduction in zooplankton (either death, avoidance, or both), including copepods, out to a distance of at least 1.2 km from the air gun source. In order for these effects to have a significant impact at an ecological scale, the spatial or temporal scale of the impulsive sound would likely need to be large in comparison to the ecosystem in question due to the naturally fast turnover rate of zooplankton (McCauley et al. 2017). While some *C. finmarchicus* could potentially be injured or killed by the use of Navy explosives and air guns, we don't anticipate that such impacts would significantly reduce the density or size of *C. finmarchicus* aggregations in the Gulf of Maine and Georges Bank region. As discussed above (Section 2.3.2), the Action Proponents will not detonate in-water explosives within the Northeast North Atlantic Right Whale Mitigation Area and will not detonate explosive sonobuoys within 3 NM of the mitigation area. These mitigation measures will further minimize any impacts on *C. finmarchicus* from explosives within North Atlantic right whale critical habitat Unit 1.

Vessel and in-water device movement within the Northeastern U.S. Foraging Area (Unit 1) could result in injury and mortality of individual *C. finmarchicus*. However, given the proposed level of vessel activity in relation to the size of Unit 1, any impacts from vessel and in-water device strike and disturbance on aggregations of *C. finmarchicus* are expected to be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). We expect that any effects to *C. finmarchicus* aggregations resulting from explosives, air guns, or vessel and in-water device movement would be highly localized and short-term, with *C. finmarchicus* densities quickly

returning to baseline (i.e., pre-disturbance) levels within the affected areas given the high turnover rate of zooplankton, in general.

Unit 2 consists of an important calving area and contains the following PBFs essential to the conservation of the species:

- Calm sea surface conditions of Force 4 or less on the Beaufort Wind Scale;
- Sea surface temperatures from a minimum of 7 °C, and never more than 17 °C; and
- Water depths of 6 to 28 m, where these features simultaneously co-occur over contiguous areas of at least 231 nm² of ocean waters during the months of November through April.

While the proposed AFTT military readiness activities would directly overlap with some of the essential features of Unit 2, very few, if any, effects are possible. For example, the proposed activities would not significantly alter the physical or oceanographic conditions within the action area, and no changes in ocean bathymetry would occur.

In summary, we find that any effects resulting from the proposed military readiness activities on North Atlantic right whale critical habitat would be insignificant. Therefore, we conclude that the proposed action may affect, but is not likely to adversely affect North Atlantic right whale critical habitat.

Rice's Whale Proposed Critical Habitat

NMFS proposed the designation of critical habitat for the Rice's whale on July 24, 2023. Rice's whale proposed critical habitat includes the area ranging from the 100 to 400 m isobaths in U.S. waters in the Gulf of America (Figure 7). Based on the best scientific information available, NMFS identified the following feature as being essential to the conservation of the Rice's whale: Gulf of America continental shelf and slope associated waters between the 100 and 400 m isobaths that support individual growth, reproduction, and development, social behavior, and overall population growth. The following attributes of this feature support Rice's whales' ability to forage, develop, communicate, reproduce, rear calves, and migrate throughout the Gulf of America continental shelf and slope waters and influence the value of the feature to the conservation of the species:

1. Sufficient density, quality, abundance, and accessibility of small demersal and vertically migrating prey species, including scombriformes, stomiiformes, myctophiformes, and myopsida;
2. Marine water with (i) elevated productivity, (ii) bottom temperatures of 10-19° C (50 to 66° F), and (iii) levels of pollutants that do not preclude or inhibit any demographic function; and
3. Sufficiently quiet conditions for normal use and occupancy, including intraspecific communication, navigation, and detection of prey, predators, and other threats.

Regarding the first attribute, small demersal and vertically migrating prey species would either not respond to the non-impulsive acoustic stressors described in Section 2.4.1 (i.e., vessel and aircraft noise, sonar, and weapons noise) or respond in a way that any effects would be

considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). While some prey species could potentially be injured or killed by impulsive AFTT stressors (i.e., explosives and air guns), we don't anticipate that such impacts would significantly reduce the density, quality, abundance or

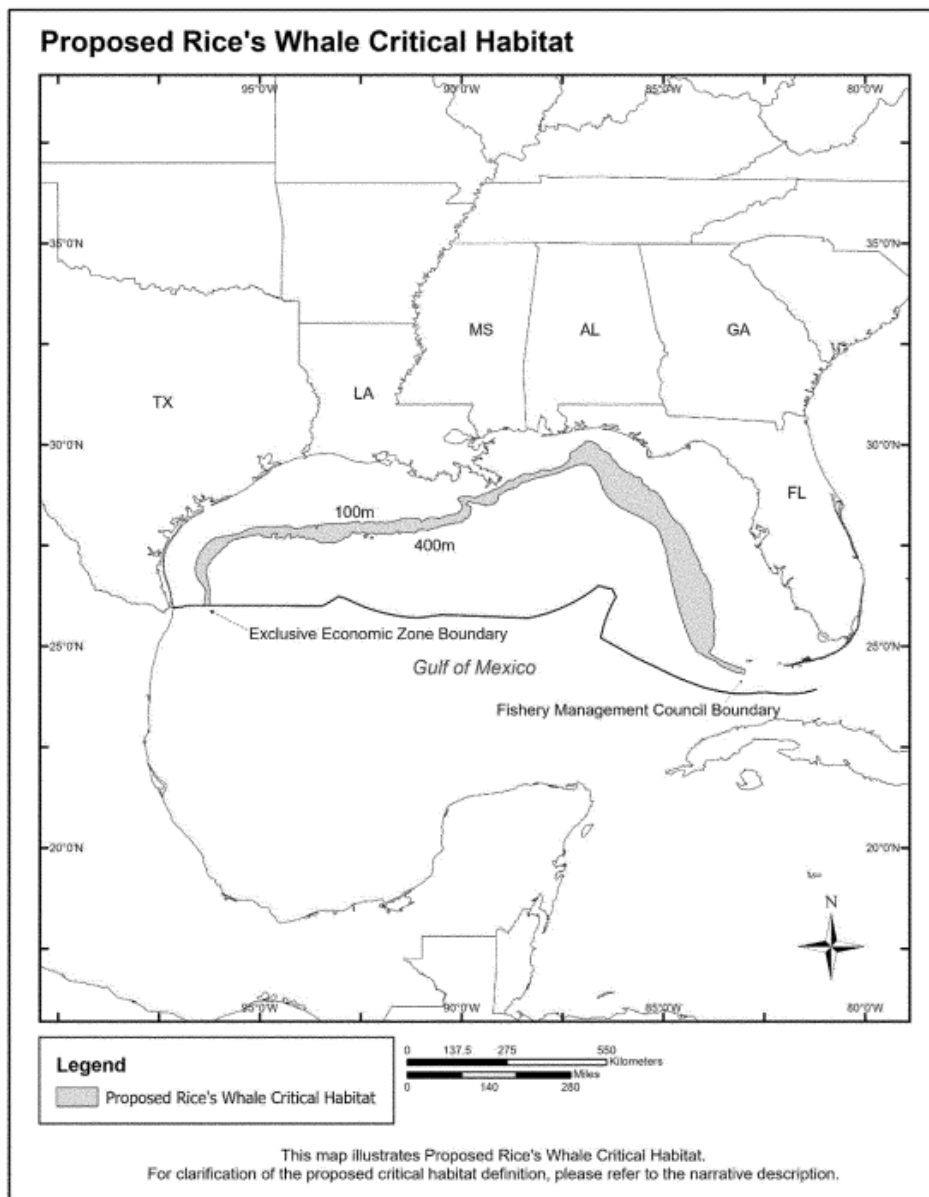


Figure 7. Area of Proposed Critical Habitat for the Rice's Whale in the Gulf of America.

accessibility of small demersal and vertically migrating prey species within Rice's whale proposed critical habitat. The abundance and density of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. If this were to occur, we would expect the effects would be short-term, only

occurring during activities involving explosives or air guns, with no lasting impact on Rice's whale prey availability or the pelagic food web, in general expected.

While some instances of Rice's whale prey injury or mortality could occur within the proposed critical habitat area, the vast majority of prey within the area will not be exposed to explosives or airguns due to the large area that has been proposed as critical habitat and the limited use of explosives or air guns within proposed critical habitat. As discussed above (Section 2.3.2), the Action Proponents will not detonate in-water explosives within the Rice's Whale Mitigation Area except during mine warfare activities. This mitigation measure will further minimize any impacts on Rice's whale prey from explosives within a large portion of proposed critical habitat that overlaps with the Rice's Whale Mitigation Area (see Figure 1 above). Thus, we expect that any effects to small demersal and vertically migrating prey species resulting from explosives or air guns within proposed critical habitat would be highly localized and short-term, with Rice's whale prey densities quickly returning to baseline (i.e., pre-disturbance) levels within the affected areas. For these reasons, the effects of explosive and air guns on the prey species attribute of Rice's whale proposed critical habitat are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Vessel and in-water device movement within proposed critical habitat could result in injury, mortality, and physical disturbance of small demersal and vertically migrating Rice's whale prey species. However, in most instances we expect demersal and vertically migrating prey species to be able to avoid being struck by vessels. Given the proposed level of vessel activity in relation to the size of the proposed critical habitat area, any impacts from vessel and in-water device strike and disturbance on this prey feature are expected to be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). We expect that any effects to demersal and vertically migrating prey species resulting from vessel and in-water device movement would be highly localized and short-term, with prey densities quickly returning to baseline (i.e., pre-disturbance) levels within the affected areas.

Regarding the second attribute above, none of the stressors (Section 2.4) associated with the proposed activities would significantly alter the productivity, bottom temperatures, or pollutant levels of the marine waters within Rice's whale proposed critical habitat. As discussed in Section 4.1.1 (*Stressors Resulting in Effects to Habitat or Prey of ESA-listed Species*), any secondary effects of stressors resulting from the proposed action on Rice's whales via impacts to water quality were found to be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Next, we consider the effects of the proposed action on the acoustic attribute of Rice's proposed critical habitat (i.e., the third attribute of the essential PBF described above). Since Rice's whales vocalize at frequencies between 60 and 160 Hz, elevation of ambient noise in the low frequency range (between 10 and 1,000 Hz) is the most likely to adversely affect Rice's whales' acoustic soundscape and use of their habitat. Noises that would impair the acoustic attribute (i.e., marine soundscape) of the proposed critical habitat are those that would inhibit normal use and

occupancy of the habitat, including Rice's whales' ability to receive and interpret sound for the purposes of navigation, communication, foraging, and detection of predators and other threats for biologically relevant time periods (e.g., hours to days). Of particular concern are anthropogenic noise sources that are long-lasting, chronic, recurrent, and/or persistent, and cumulatively inhibit and/or mask the animals' ability to receive and interpret sound (e.g., opportunities to forage or reproduce).

As we will discuss in Section 6.1.1, we anticipate that exposure of individual Rice's whales to AFTT sonar and explosives will result in significant behavioral responses, sound-induced hearing loss (e.g., TTS and AINJ), as well as other possible adverse effects (e.g., stress). When marine mammals experience these effects, their ability to carry out important life functions (e.g., foraging, navigating, or communicating) may be impaired for some period of time. When evaluating whether a sound source has decreased the value of critical habitat for conservation, we must consider the timing, frequency, and duration of the sound, as well as the spatial extent of impacts when they occur relative to the area of critical habitat. While individual whales could experience adverse effects that last hours, days or potentially even longer (e.g., permanent threshold shift [PTS]), the effects to the marine soundscape resulting from AFTT sound sources would be of much shorter duration. Thus, although Rice's whales may exhibit behavioral responses or suffer auditory injury from short-duration sound exposures, a longer period, like hours to days, is considered biologically relevant in the context of what may affect their normal use and occupancy of their habitat for purposes of evaluating the effects on the sound related attribute of the proposed critical habitat PBF.

Further, in order to significantly degrade the acoustic value of the proposed critical habitat to the whales, anthropogenic noise would need to, either alone or combined with other noises, significantly raise sound levels over a significant portion of an area (in terms of size and use by the whales) on a prolonged basis (e.g., months to years). Degraded soundscape conditions are a somewhat unique habitat attribute in that they can return almost immediately to baseline conditions after a noise source is removed or modified. Therefore, occasional or infrequent sound sources (i.e., AFTT explosives, sonar or air guns proposed in critical habitat), even those that are detectable by Rice's whales and result in behavioral responses or auditory impacts, are not the types of activities that are anticipated to impact the acoustic attribute of proposed critical habitat over biologically relevant time periods.

Sonar exposures are more likely to be consequential to the animal if they are for long durations or occur repeatedly (Southall et al. 2007; Southall et al. 2016). Similarly, sonar use is more likely to result in significant impairment to the use or occupancy of the habitat at a population level if the habitat is subjected to long duration or repeated exposures. Most sonar systems used for AFTT military readiness activities in the Gulf Range Complex operate at mid- to high frequencies (Navy 2024c), whereas Rice's whales vocalize at very low frequencies. While continuous active sonar or other high-duty sonar sources may overlap with Rice's whale critical habitat, the proposed action would not introduce any chronic or long-lasting, low-frequency

noise (Navy 2024c) that could adversely affect the Rice's whales' acoustic soundscape and their use and occupancy of areas designated as proposed critical habitat.

As discussed above (*Acoustic Stressors NLAA*, Section 4.1.1), other acoustic stressors (e.g., vessel, aircraft, and weapons noise) within Rice's whale proposed critical habitat would be intermittent and sporadic in nature, and widely dispersed over a large area. None of the sound sources within Rice's whale critical habitat resulting from the proposed action would be long-lasting, chronic, recurrent, and/or persistent in space and time. Proposed mitigation measures within the Rice's Whale Mitigation Area (Table 24), which makes up a large portion of the critical habitat area, will likely further minimize any impacts to the acoustic attribute of Rice's whale proposed critical habitat.

The Panama City Testing Range is in the center of the Rice's whale core distribution area (as shown in Figure 22 below) and represents a large and very important part of the proposed critical habitat (Figure 8). Action Proponent sound producing activities proposed for AFTT Phase IV that could overlap with Rice's whale proposed critical habitat within the Panama City Testing Range include Mine Countermeasure and Neutralization Testing, Mine Countermeasure Mission Package Testing, Mine Detection and Classification Testing, Unmanned Underwater Vehicle Testing, Insertion/Extraction, Line Charge Testing, and Semi-Stationary Equipment Testing. During NMFS's ESA listing status review for Rice's whales, Rosel (2016) reviewed available acoustic data from long-term passive acoustic monitoring recorders operating from May 2010 to December 2014 to understand and characterize the whales' acoustic environment. The two sites in the core distribution area had substantially lower ambient noise levels than the other assessed sites throughout the northern Gulf of America, where oil and gas operations and other commercial activities are more prevalent. Similarly, the LISTEN Gulf of Mexico (GoMex) project compiled acoustic monitoring recordings from 2010-2020 at five sites in the northern Gulf of America and found that the Desoto Canyon, which is within the core distribution area and the Panama City Testing Range, remained the quietest site. More recent LISTEN GoMex monitoring results from 2020 to 2023 at eight long-term monitoring sites from around the Gulf of America, plus 13 additional shorter-term acoustic monitoring locations, confirm that sites monitored within the core distribution area remain the quietest locations in the northern Gulf of America (Frasier et al. 2024b). The ambient noise levels measured in the core distribution area integrate any low frequency noise from Navy and Air Force testing and training that occurred close enough (i.e., loud enough) to be detected.

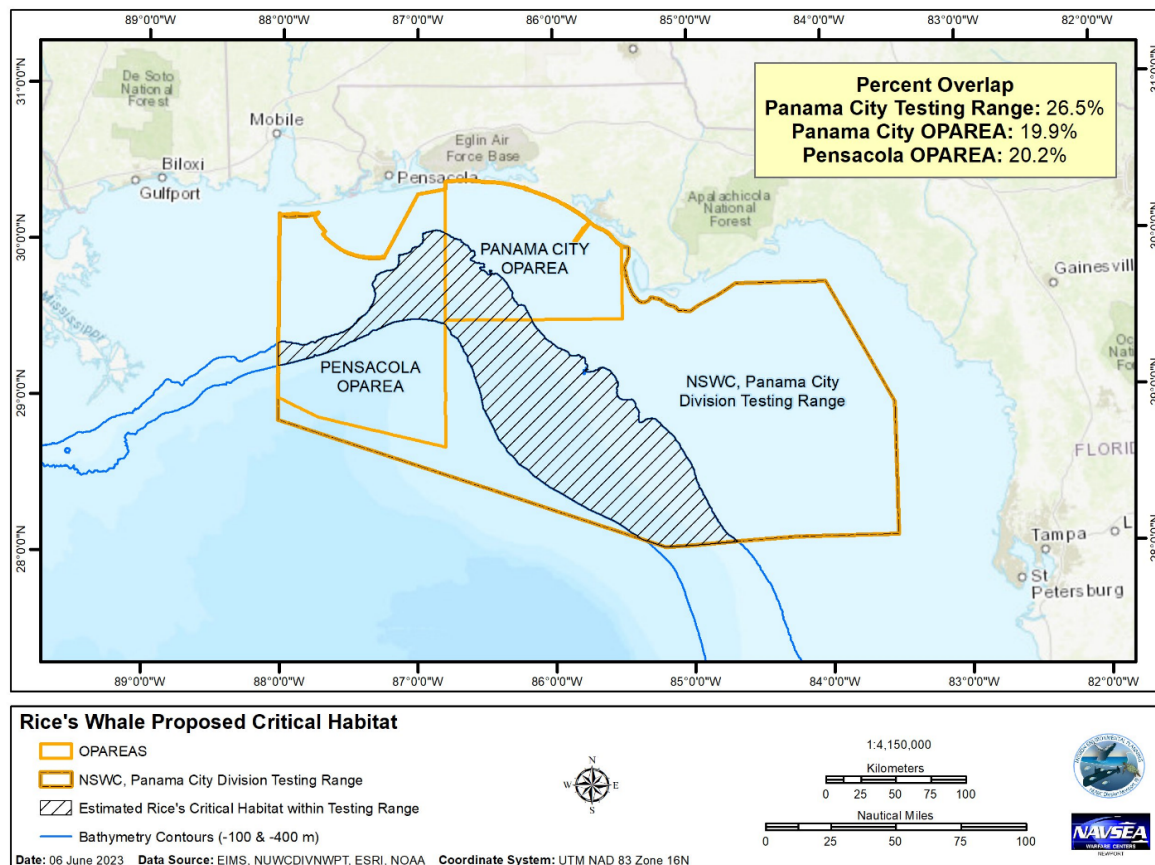


Figure 8. Overlap between Proposed Rice's Whale Critical Habitat and the Navy's Panama City Testing Range, Panama City OPAREA and Pensacola OPAREA

Figure 9 shows the 100 Hz and 150 Hz ambient sound pressure spectrum levels at LISTEN GoMex Sites from 2020 to 2022. The two sites within the core distribution area (i.e., Desoto Canyon [DC] and Y1D at the southern end of the core distribution) show the lowest ambient sound pressure levels at 100 and 150 Hz within the northern Gulf of America. Thus, based on the available information, our assessment is that ongoing military activities over the 2010 to 2023 period have not been compromising the acoustic attribute, or normal use and occupancy, of proposed Rice's whale critical habitat.

Based on passive acoustic monitoring for over a decade, the area of overlap between AFTT sound producing activities and Rice's whale proposed critical habitat consistently provide some of the quietest conditions for Rice's whales recorded in the northern Gulf of America. We have no reason to believe that this will change in the reasonably foreseeable future, given that the proposed AFTT Phase IV sound producing activities and activity levels within critical habitat are similar (or less than) those in previous phases of AFTT. Additionally, the presence of active military testing and training in the Panama City Testing Range likely has the indirect benefit of discouraging other commercial uses of those waters, such as shipping and oil and gas

exploration, both of which contribute substantially to the higher levels of chronic low-frequency noise in other areas of the Gulf of America.

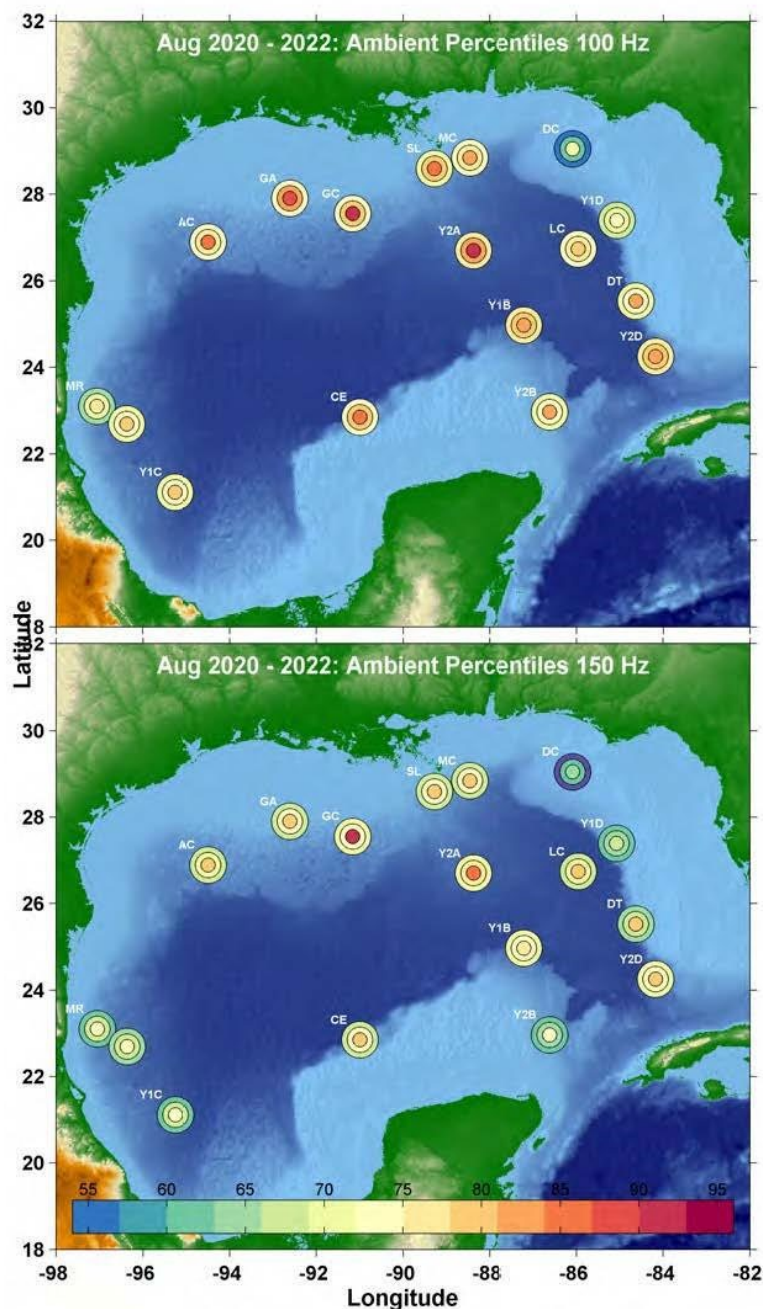


Figure 9. 100 Hz and 150 Hz Ambient Sound Pressure Spectrum Levels at LISTEN GoMex Sites from 2020-2022 (Frasier et al. 2024b) Although sound from AFTT sonar and explosives could affect the Rice's whale marine soundscape, any effects to the marine soundscape from these stressors will be relatively minor and/or short in duration. For this and other reasons discussed above, we believe that the effects of the proposed action will not adversely modify the acoustic attribute, or any other attribute, of the proposed Rice's critical habitat's essential feature. Therefore, we find that

any effects resulting from the proposed military readiness activities on Rice's whale proposed critical habitat would be insignificant. Thus, we conclude that the proposed action may affect, but is not likely to adversely affect Rice's whale proposed critical habitat.

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

On July 10, 2014, NMFS and the U.S. Fish and Wildlife Service designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtles (79 FR 39856; Figure 10).

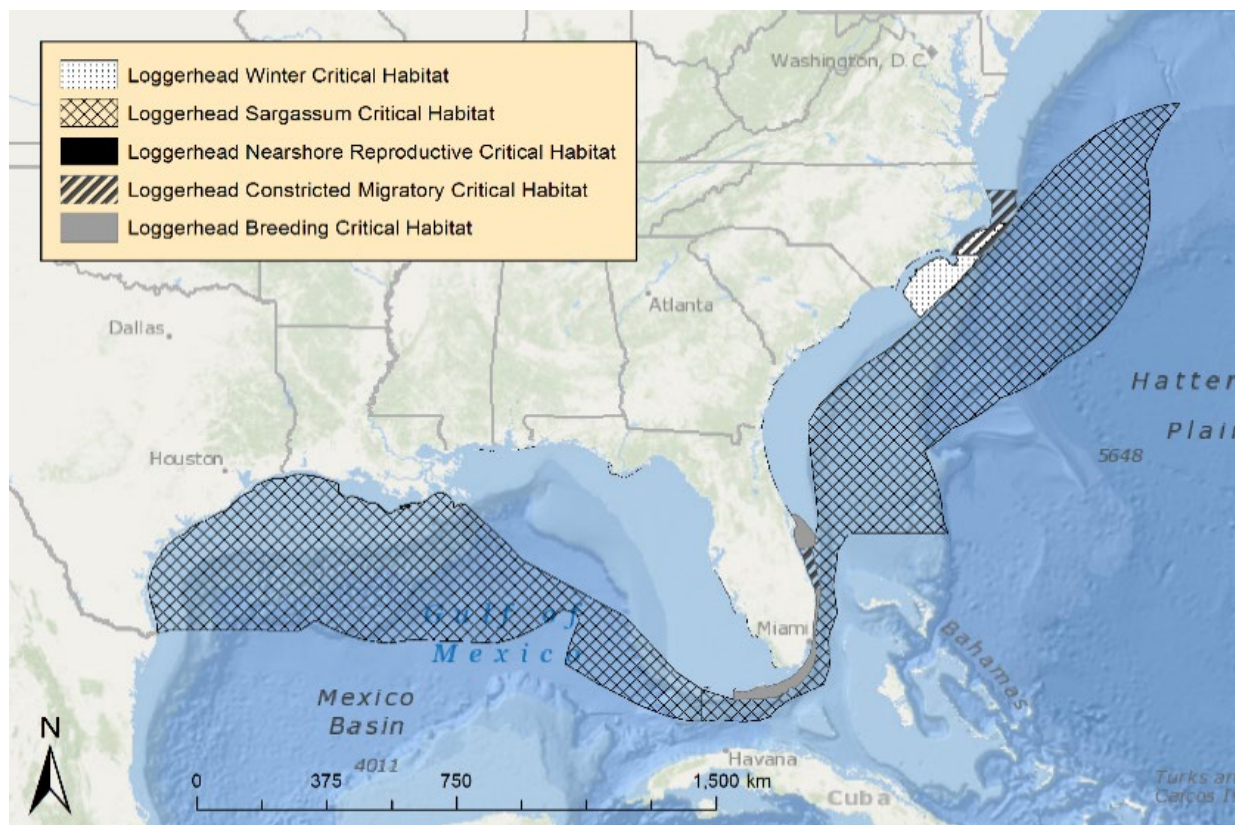


Figure 10. Designated Critical Habitat for the Northwest Atlantic Ocean DPS of Loggerhead Sea Turtles.

Designated critical habitat includes five different units, each supporting an essential biological function for loggerhead sea turtles. These units include nearshore reproductive habitat, winter habitat, Sargassum habitat, breeding habitat, and constricted migratory habitat. The essential PBFs of each unit of designated critical habitat are shown in Table 44. Designated critical habitat occurs within the action area, along the U.S. Atlantic and Gulf of America coasts, from North Carolina to Mississippi. Within the action area, loggerhead critical habitat may be affected by acoustic stressors and explosives. These stressors will not affect nearshore reproductive, winter, and breeding critical habitat since: 1) the proposed activities that produce these stressors will not occur in these areas or 2) there is no pathway to effects to the PBFs within these critical habitat units resulting from these stressors. However, the constricted migratory habitat and *Sargassum*

habitat units may be affected by these stressors. Our analysis below focuses on the PBFs of these two units that may be affected by the proposed action.

Table 44. Physical and Biological Features within each Critical Habitat Unit for the Northwest Atlantic Ocean DPS of Loggerhead Sea Turtle

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

All of the stressors described above have the potential to affect passage conditions that allow for migration of loggerhead turtles to and from nesting, breeding, and/or foraging areas. Specifically, the common stressor of noise produced by sonar and other transducers, air guns, vessels, weapons, and explosives may alter designated constricted migratory critical habitat such that sea turtles may avoid this habitat or alter their migration. However, based on the frequency of these activities, their temporary nature, their relatively small footprint at any given time compared to the amount of available migratory habitat, and given that the activities would be spread across a

large geographic area, noise produced by these activities is not likely to have significant effects on passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas. This determination is also based on the fact that sea turtles are not known to rely heavily on sound for life functions (Popper et al. 2014; Nelms et al. 2016), and instead appear to rely on other senses such as vision (Narazaki et al. 2013), chemical cues (Endres et al. 2016), and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015). In addition, many of the sound sources resulting from the proposed action are outside of sea turtle hearing range, which is most sensitive from 100 to 400 Hz and limited over 1 kHz. As such, while noise from the proposed action may have minor effects on passage conditions within constricted migratory critical habitat, it is not expected to have meaningful effects on the conservation value of critical habitat for loggerhead sea turtles. Thus, the effects of acoustic stressors associated with the proposed action on designated constricted migratory critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

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

The use of explosives has the potential to affect *Sargassum* concentrations that support adequate prey abundance and cover, as well as available prey and other material associated with

Sargassum habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods. Detonation of explosive devices near or within *Sargassum* would destroy *Sargassum* as well as nearby prey. Explosions produce pressure waves with the potential to cause injury or physical disturbance to invertebrate prey such as copepods due to rapid pressure changes, as well as loud, impulsive, broadband sounds. Most marine invertebrates, including copepods and hydroids, lack air cavities and are therefore comparatively less vulnerable to the damaging effects of pressure waves. Additionally, when explosive munitions detonate, fragments of the weapon are thrown at high velocity from the detonation point, which can injure or kill invertebrates if they are struck. However, the friction of the water quickly slows these fragments to the point where the explosion would have to be very close to prey to pose a threat.

The majority of prey available to loggerhead sea turtles in designated *Sargassum* critical habitat are expected to be near the surface (Witherington et al. 2012a), where many of the proposed explosives would occur. As such, the use of explosives in designated *Sargassum* critical habitat is expected to affect the PBFs of *Sargassum* habitat due to both the physical destruction of nearby *Sargassum* and prey caused by fragments, as well the effects of noise produced by explosives, which may impact prey well beyond the immediate vicinity of the explosion. However, such impacts are expected to be relatively minor and temporary given the high turnover rate of zooplankton and the currents in the North Atlantic gyre and the Gulf Stream, which would circulate *Sargassum* into designated loggerhead critical habitat within the action area (see Richardson et al. 2017 for simulations based on the results of McCauley et al. 2017 that suggest ocean circulation greatly reduced the impact of seismic surveys on zooplankton at the population level). Moreover, as discussed in Section 2.3.2 the Action Proponents will use Lookouts to search for floating vegetation, including *Sargassum* mats, and not use explosives if floating vegetation is observed. Given these reasons, the effects of explosives on designated *Sargassum* critical habitat is expected to be minor and localized.

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

In conclusion, the proposed action may affect, but is not is likely to adversely affect, designated critical habitat for the loggerhead sea turtle Northwest Atlantic Ocean DPS.

Green Sea Turtle – North Atlantic DPS Proposed Critical Habitat

On July 19, 2023, NMFS issued a proposed rule to designate marine critical habitat for six DPSs of green sea turtles (88 FR 46572). Proposed critical habitat for the North Atlantic DPS includes nearshore areas from the mean high water line to 20 m depth located along the coasts of Florida, North Carolina, Texas, and Puerto Rico (NMFS 2023b). It also includes *Sargassum* habitat, from

10 m depth to the outer boundary of the U.S. EEZ, in the Gulf of America and Atlantic Ocean (Figure 11).

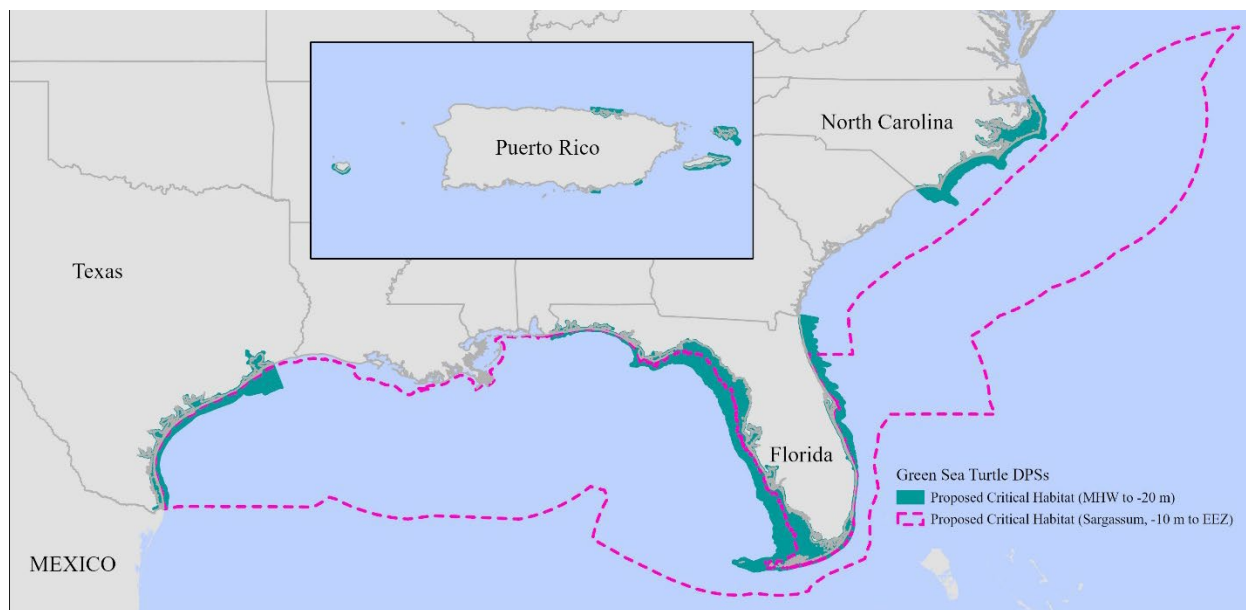


Figure 11. Proposed Marine Critical Habitat for the Green Sea Turtle North Atlantic DPS

Physical and biological features essential to the conservation of the green sea turtle North Atlantic DPS include:

- Reproductive: From the mean high water line to 20 m depth, sufficiently dark and unobstructed nearshore waters adjacent to nesting beaches designated as critical habitat by USFWS, to allow for the transit, mating, and internesting of reproductive individuals and the transit of post-hatchlings.
- Migratory: From the mean high water line to 20 m depth, sufficiently unobstructed waters that allow for unrestricted transit of reproductive individuals between benthic foraging/resting and reproductive areas.
- Benthic foraging/resting: From the mean high water line to 20 m depth, underwater refugia and food resources (i.e., seagrasses, macroalgae, and/or invertebrates) of sufficient condition, distribution, diversity, abundance, and density necessary to support survival, development, growth, and/or reproduction.
- Surface-pelagic foraging/resting (“Sargassum”): Convergence zones, frontal zones, surface-water down-welling areas, the margins of major boundary currents, and other areas that result in concentrated components of the Sargassum-dominated drift community, as well as the currents which carry turtles to Sargassum-dominated drift communities, which provide sufficient food resources and refugia to support the survival, growth, and development of post-hatchlings and surface-pelagic juveniles, and which are located in sufficient water depth (at least 10 m) to ensure offshore

transport via ocean currents to areas which meet forage and refugia requirements (NMFS 2023b).

Within the action area, green sea turtle proposed critical habitat may be affected by acoustic stressors and explosives. These stressors will not affect proposed reproductive critical habitat since there is no pathway to effects to the PBFs within this critical habitat unit resulting from these stressors. However, the proposed migratory, benthic foraging/resting, and *Sargassum* habitat units may be affected by these stressors. Our analysis below focuses on the PBFs of these three units that may be affected by the proposed action.

The acoustic stressors described above have the potential to affect passage conditions that allow for migration of green sea turtles to and from benthic foraging/resting and reproductive areas. Specifically, the common stressor of noise produced by sonar and other transducers, air guns, vessels, weapons, and explosives may alter proposed migratory critical habitat such that sea turtles may avoid this habitat or alter their migration. However, based on the frequency of these activities, their temporary nature, their relatively small footprint at any given time compared to the amount of available migratory habitat, and given that the activities would be spread across a large geographic area, the effects of noise produced by these activities are not likely to have significant effects on passage conditions to allow for migration between benthic foraging/resting and reproductive areas. This determination is also based on the fact that sea turtles are not known to rely heavily on sound for life functions (Popper et al. 2014; Nelms et al. 2016), and instead appear to rely on other senses such as vision (Narazaki et al. 2013), chemical cues (Endres et al. 2016), and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015). In addition, many of the sound sources resulting from the proposed action are outside of sea turtle hearing range, which is most sensitive from 100 to 400 Hz and limited over 1 kHz. As such, while noise from the proposed action may have minor effects on passage conditions within migratory critical habitat, it is not expected to have meaningful effects on the conservation value of proposed critical habitat for green sea turtles (North Atlantic Ocean DPS). Thus, the effects of acoustic stressors associated with the proposed action on proposed migratory critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

The proposed action may also affect benthic foraging/resting and surface-pelagic foraging/resting ("*Sargassum*") proposed critical habitat due to the effects of sonar and transducers, air guns and explosives. Specifically, the food resources (i.e., prey) PBF feature of these units may be affected.

We are not aware of any research examining the effects of active sonar on sea turtle prey species in either nearshore benthic foraging or *Sargassum* habitat, although the sound produced by sonar is not anticipated to cause mortality or injury to green sea turtle prey species due to the lack of fast rise times, high peak pressures, and the lack of high acoustic impulse of sonar. However, explosives may elicit behavioral responses from prey. Invertebrate species generally have their greatest sensitivity to sound below one to three kHz (Kunc et al. 2016) and would therefore not be capable of detecting mid- or high-frequency sounds, including the majority of sonars, or

distant sounds in the action area, though some invertebrate prey could likely detect low-frequency sonars. Research has documented behavioral responses of other invertebrates (i.e., squid, crabs) to anthropogenic noise (McCauley et al. 2000b) (Lagardere 1982; Wilson et al. 2007) and we assume that at least some species of green sea turtle prey may exhibit a behavioral response if exposed to low-frequency sonars similar to these species. However, we anticipate no harm will occur to these exposed animals, and they will resume normal behaviors immediately after the sound exposure is over and remain available to green sea turtles foraging in the area. Additionally, we expect that the Action Proponent's proposed mitigation to avoid the use of active sonar near floating vegetation, including *Sargassum*, would reduce the source levels prey associated with *Sargassum* would be exposed to, thereby minimizing any potential behavioral response they may exhibit. As such, while sonar and other transducers may affect prey in proposed benthic foraging/resting and *Sargassum* critical habitat, they are not expected to have meaningful effects on the conservation value of proposed critical habitat for green sea turtles (North Atlantic Ocean DPS). Thus, the effects of sonar and other transducers on benthic foraging/resting and surface-pelagic foraging/resting ("*Sargassum*") proposed critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

The use of explosives has the potential to affect green sea turtle nearshore benthic and *Sargassum* food resources (i.e., seagrasses, macroalgae, and/or invertebrates). Explosions produce pressure waves with the potential to cause injury or physical disturbance to invertebrate prey such as copepods due to rapid pressure changes, as well as loud, impulsive, broadband sounds. Most marine invertebrates, including copepods and hydroids, lack air cavities and are therefore comparatively less vulnerable to the damaging effects of pressure waves. Additionally, when explosive munitions detonate, fragments of the weapon are thrown at high velocity from the detonation point, which can injure or kill invertebrates if they are struck. However, the friction of the water quickly slows these fragments to the point where the explosion would have to be very close to prey to pose a threat.

The majority of prey available to green sea turtles in *Sargassum* habitat are expected to be near the surface (Witherington et al. 2012a), where many of the proposed explosives would occur. As such, the use of explosives in *Sargassum* proposed critical habitat is expected to affect the PBFs of *Sargassum* habitat due to both the physical destruction of nearby *Sargassum* and prey caused by fragments, as well the effects of noise produced by explosives, which may impact prey well beyond the immediate vicinity of the explosion. However, such impacts are expected to be relatively minor and temporary given the high turnover rate of zooplankton and the currents in the North Atlantic gyre and the Gulf Stream, which would circulate *Sargassum* into proposed critical habitat within the action area (see Richardson et al. 2017 for simulations based on the results of McCauley et al. 2017 that suggest ocean circulation greatly reduced the impact of seismic surveys on zooplankton at the population level). Moreover, as discussed in Section 2.3.2 the Action Proponents will use Lookouts to search for floating vegetation, including *Sargassum* mats, and not use explosives if floating vegetation is observed. Given these reasons, the effects of explosives on *Sargassum* proposed critical habitat is expected to be minor and localized.

Prey available to green sea turtles in benthic foraging habitat are expected to be at or near the seafloor. This critical habitat unit would be affected by in-water explosives that are detonated on the seafloor due to both the physical destruction of prey caused by fragments, as well the effects of noise produced by explosives throughout the water column, which may impact prey well beyond the immediate vicinity of the explosion. The use of explosives in proposed nearshore benthic foraging habitat will be limited, in general, since most explosive detonations will occur in waters greater than 200 ft in depth and greater than 3 NM from shore. We anticipate a small number of mine warfare, demolition, amphibious warfare, and some testing detonations could occur in shallow water areas proposed as green sea turtle critical habitat (Navy 2024c). Any impacts from these activities are expected to be minor, localized and temporary, as prey resources are expected to quickly repopulate the area in sufficient abundance and density necessary to support survival, development, growth, and/or reproduction of green sea turtles.

As such, while the use of explosives may temporarily alter prey abundance in benthic foraging/resting and surface-pelagic foraging/resting (“*Sargassum*”) proposed critical habitat, it is not expected to have meaningful effects on the conservation value of proposed critical habitat for green sea turtles (North Atlantic Ocean DPS). Thus, the effects of explosives on proposed critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). In conclusion, the proposed action may affect, but is not likely to adversely affect, proposed critical habitat for the green sea turtle North Atlantic Ocean DPS.

Atlantic Sturgeon Designated Critical Habitat

On September 18, 2017, NMFS designated critical habitat for Atlantic sturgeon (82 FR 39160). Designated critical habitat for the endangered New York Bight DPS, the endangered Chesapeake Bay DPS, the endangered Carolina DPS, and the endangered South Atlantic DPS of Atlantic sturgeon occurs within the action area, in coastal rivers from Maine to Florida (Figure 12).

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

1. Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 parts per thousand range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
2. Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 parts per thousand and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;
3. Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of sub adults or spawning condition adults. Water depths in main river

channels must also be deep enough (e.g., at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river;

4. Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support:
 - (i) Spawning;
 - (ii) Annual and inter-annual adult, sub adult, larval, and juvenile survival;
 - and (iii) Larval, juvenile, and sub adult growth, development, and recruitment (e.g., 13 to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) or greater dissolved oxygen (DO) for juvenile rearing habitat).

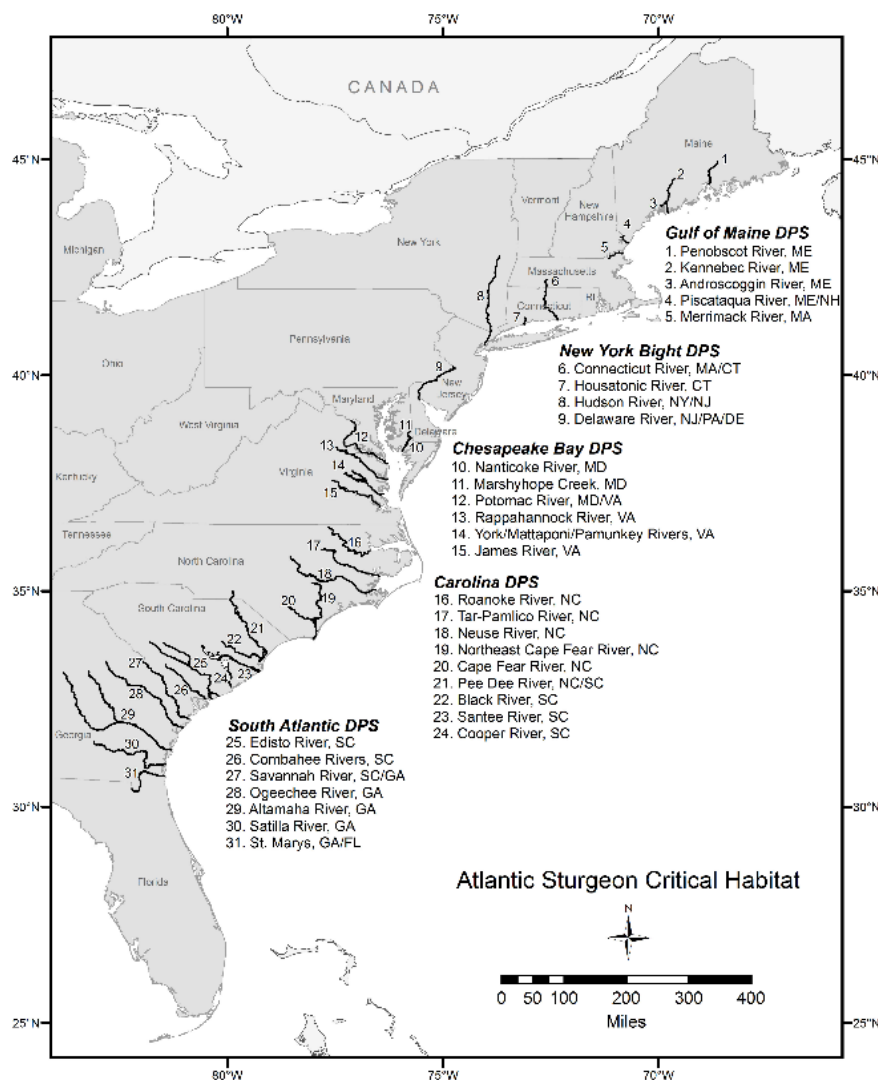


Figure 12. Map Showing the 31 Coastal Rivers Designated as Critical Habitat for Atlantic Sturgeon

The PBFs essential for the conservation of Atlantic sturgeon belonging to the Carolina, and South Atlantic DPSs are:

1. Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 parts per thousand range) for settlement of fertilized eggs and refuge, growth, and development of early life stages;
2. Aquatic habitat inclusive of waters with a gradual downstream gradient of 0.5 up to as high as 30 parts per thousand and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;
3. Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of sub adults or spawning condition adults. Water depths in main river channels must also be deep enough (at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river;
4. Water quality conditions, especially in the bottom meter of the water column, with temperature and oxygen values that support” (i) Spawning; (ii) Annual and inter-annual adult, sub adult, larval, and juvenile survival; and (iii) Larval, juvenile, and sub adult growth, development, and recruitment. Appropriate temperature and oxygen values will vary interdependently, and depending on salinity in a particular habitat. For example, 6.0 mg/L DO or greater likely supports juvenile rearing habitat, whereas DO 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, DO greater than 4.3 mg/L is needed to protect survival and growth. Temperatures of 13 to 26 °C likely support spawning habitat.

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

The physical presence of objects such as vessels and in-water devices may act as a physical obstacle that could alter sturgeon movement, while activities that produce noise that would be audible to sturgeon (e.g., mid and low-frequency sonar, vessel noise) may act as a sonic obstacle that could alter sturgeon movement. However, we anticipate the effects of these stressors on Atlantic sturgeon movement and passage would be temporary and minor for several reasons. First, the proposed activities will not occur in any migration corridor for a duration that would alter sturgeon movement, or impede sturgeon from accessing spawning or rearing habitat. Second, the effects on passage are expected to be localized and only occur in a portion of the water column (e.g., vessels at the surface, seafloor devices at the seafloor), meaning there would not be a complete blockage of passage, likely only temporary, minor changes in sturgeon

movement to avoid the immediate vicinity of AFTT activities. The placement or expenditure of objects in areas of designated Atlantic sturgeon critical habitat characterized by soft substrate would cover the substrate for a relatively short period of time in the case of seafloor devices (which are retrieved), or in the case of expended military material, until the object degrades or is covered by additional sediment. However, only a small portion of soft substrate would be covered and unavailable. In addition, after the removal of the seafloor device, or degradation or covering of expended military material, this habitat is expected to become available again for Atlantic sturgeon to utilize. Therefore, we do not anticipate that the use of seafloor devices and expended military material would have meaningful effects on the conservation value of designated Atlantic sturgeon critical habitat. Thus, the effects of seafloor devices and expended military material on soft substrate in designated Atlantic sturgeon critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

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

We have determined that the stressors resulting from the proposed action will not affect the other Atlantic sturgeon critical habitat PBFs listed above (e.g., bottom substrate and salinity conditions in riverine habitats, and water quality conditions). These PBFs would either not overlap with AFTT stressors (e.g., PBFs in spawning and early life stage habitats) or there would be no pathway to effects (e.g. water depth or salinity). See Section 4.1.1 (Stressors Resulting in Effects to Habitat or Prey of ESA-listed Species) for a discussion of stressors not likely to adversely affect habitat or prey of ESA-listed species, in general.

In conclusion, the proposed action may affect, but is not is likely to adversely affect, Atlantic sturgeon designated critical habitat (all DPSs, except Gulf of Maine DPS which does not overlap with the proposed action area).

Nassau Grouper Designated Critical Habitat

Nassau Grouper critical habitat encompasses approximately 2,384.67 sq. km (920.73 sq. miles) of aquatic habitat located in waters off the southeastern coast of Florida (Figure 13), Puerto Rico, Navassa, and the United States Virgin Islands (Figure 14). The physical and biological features

(PBFs) features that have been identified as essential to the conservation of Nassau grouper, are as follows:

1. Recruitment and developmental habitat. Areas from nearshore to offshore necessary for recruitment, development, and growth of Nassau grouper containing a variety of benthic types that provide cover from predators and habitat for prey, consisting of the following:
 - a. Nearshore shallow subtidal marine nursery areas with substrate that consists of unconsolidated calcareous medium to very coarse sediments (not fine sand) and shell and coral fragments and may also include cobble, boulders, whole corals and shells, or rubble mounds, to support larval settlement and provide shelter from predators during growth and habitat for prey.
 - b. Intermediate hard bottom and seagrass areas in close proximity to the nearshore shallow subtidal marine nursery areas that provide refuge and prey resources for juvenile fish. The areas include seagrass interspersed with areas of rubble, boulders, shell fragments, or other forms of cover; inshore patch and fore reefs that provide crevices and holes; or substrates interspersed with scattered sponges, octocorals, rock and macroalgal patches, or stony corals.
 - c. Offshore Linear and Patch Reefs in close proximity to intermediate hard bottom and seagrass areas that contain multiple benthic types, for example, coral reef, colonized hard bottom, sponge habitat, coral rubble, rocky outcrops, or ledges, to provide shelter from predation during maturation and habitat for prey.
 - d. Structures between the subtidal nearshore area and the intermediate hard bottom and seagrass area and the offshore reef area including overhangs, crevices, depressions, blowout ledges, holes, and other types of formations of varying sizes and complexity to support juveniles and adults as movement corridors that include temporary refuge that reduces predation risk as Nassau grouper move from nearshore to offshore habitats.
2. Spawning Habitat. Marine sites used for spawning and adjacent waters that support movement and staging associated with spawning.

Approximately 800 ac (3.2 km²) of Nassau grouper critical habitat overlaps waters of the action area and has been identified in the Naval Air Station Key West Integrated Natural Resources Management Plan (Navy 2020). NMFS determined that the Integrated Natural Resources Management Plan provides benefits to Nassau grouper and areas included in the critical habitat. Therefore, pursuant to section 4(a)(3)(B)(i) of the ESA, NMFS determined that areas covered by the Integrated Natural Resources Management Plan are ineligible for designation as critical habitat for Nassau grouper. The proposed action contains three stressors that could have impacts to Nassau grouper critical habitat, the use of explosives in water, use of seafloor devices, and military expended materials. The small area of critical habitat that is seaward of coastal waters is also within the Florida Key National Marine Sanctuary where the Action Proponents have agreed not to release of military expended materials with the exception of Demolition Key, where the critical habitat area does not occur.

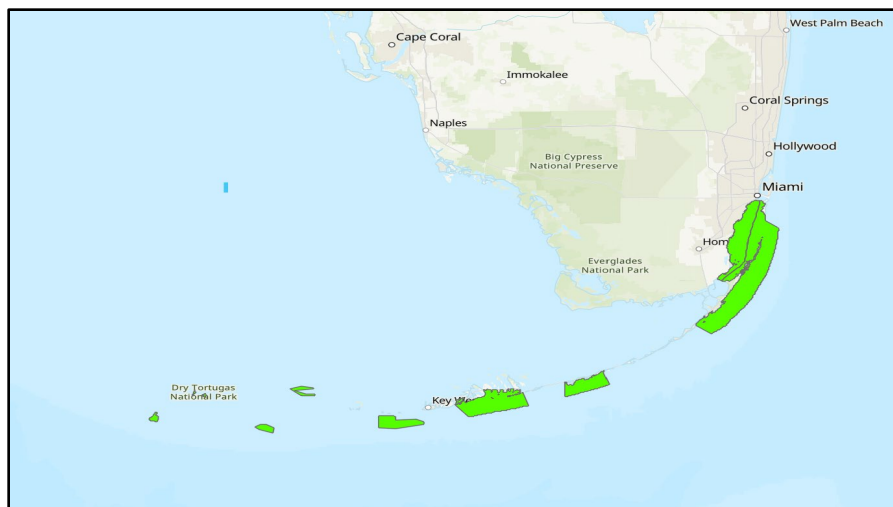


Figure 13. Nassau Grouper Critical Habitat South Florida

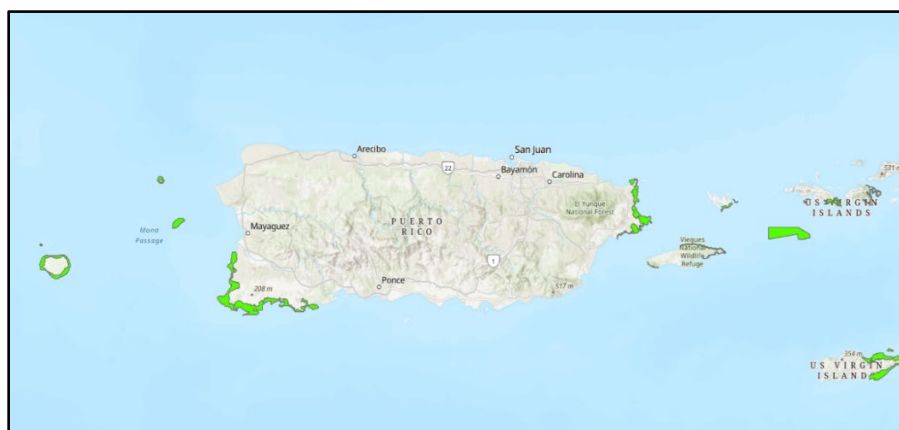


Figure 14. Nassau Grouper Critical Habitat Puerto Rico and US Virgin Islands

PBF1 identifies nearshore to offshore areas necessary for recruitment, development, and growth, containing a variety of benthic types that provide cover from predators and habitat for prey. This PBF does have potential to be impacted from the proposed action. In the mitigation and minimization protocols identified in Section 2.3.2, the Action Proponents will not detonate any in-water explosives (including underwater explosives and explosives deployed against surface targets) within a horizontal distance of 350 yd from shallow-water coral reefs. The 350-yd mitigation area radius is designed to prevent direct impacts (and some level of indirect impacts) from explosives on artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks. Mitigation measures also exclude placement of expended non-explosive mine shapes and anchors on Nassau grouper habitat. These mitigation measures ensure that the explosive effects most likely to impact Nassau Grouper critical habitat are minimized and not conducted in the most sensitive areas identified as the PBFs considered essential to the conservation of Nassau grouper. Given the very small area of Nassau grouper critical habitat the overlaps with the proposed action, and the mitigation measures in place to minimize impacts on

this habitat, we find any effects from explosives, seafloor devices or military expended materials on PBF 1 to be insignificant.

PBF 2 identifies the need for marine sites used for spawning and adjacent waters that support movement and staging associated with spawning. 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 and Eklund 1999). Within the action area, spawning aggregations have only been documented around Bermuda, Puerto Rico and the U.S. Virgin Islands (National Marine Fisheries Service 2013) and there are no identified spawning aggregation sites that overlap with AFTT stressors (i.e., explosives, seafloor devices, and military expended materials) that could result in adverse effects to this PBF.

Therefore, since any potential effects of stressors resulting from the proposed action on the PBFs of Nassau grouper critical habitat are insignificant, we conclude that the proposed action may affect, but is not likely to adversely affect, Nassau grouper designated critical habitat.

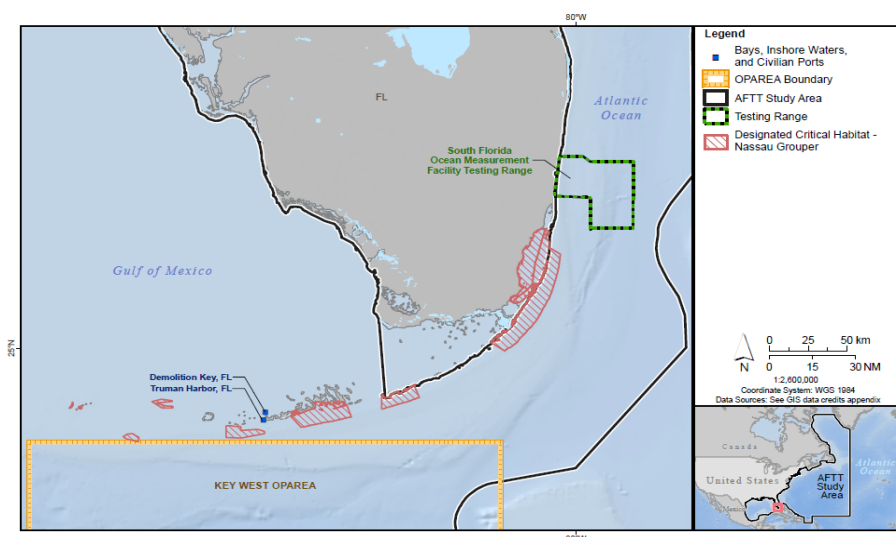
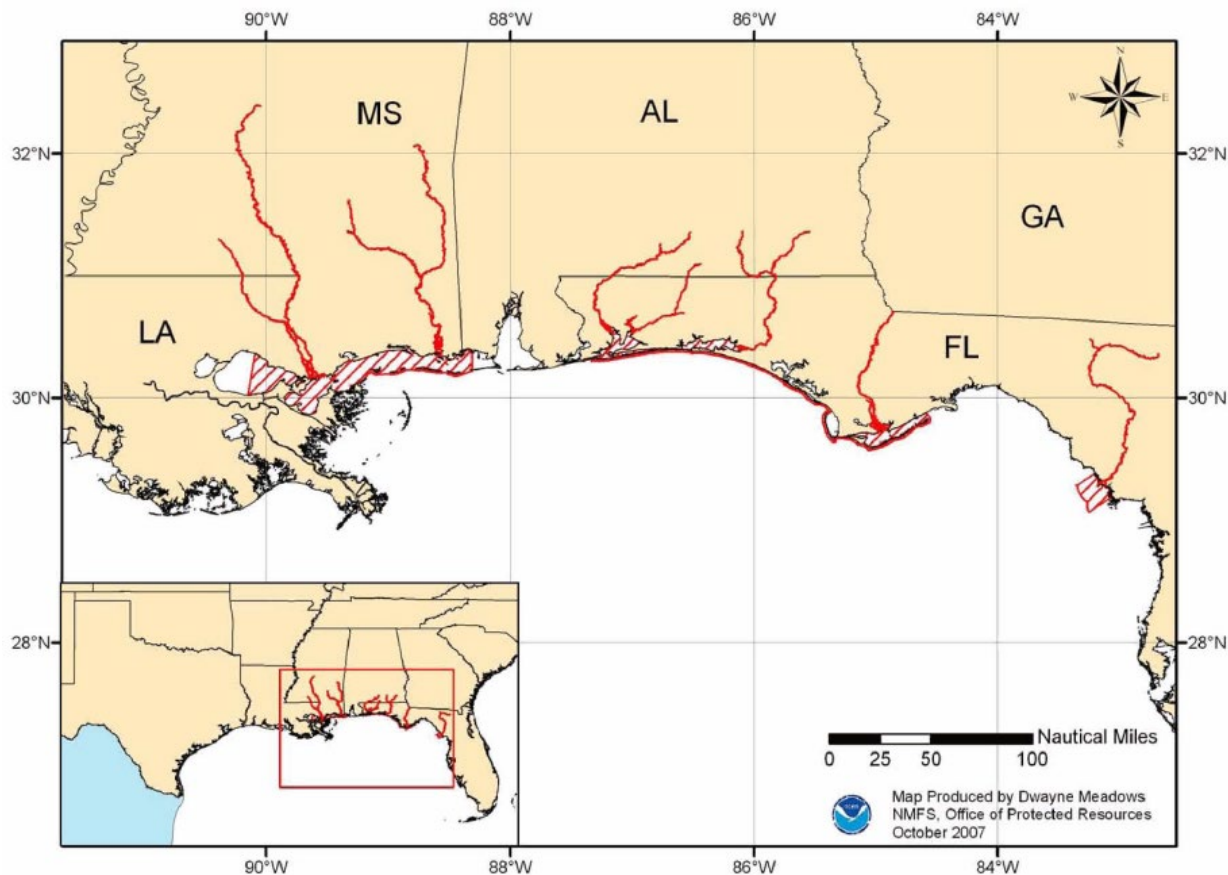


Figure 15. Designated Critical Habitat for Nassau Grouper within the AFTT Action Area

Gulf Sturgeon Designated Critical Habitat

Designated critical habitat for Gulf sturgeon occurs within the action area and consists of 14 geographic units encompassing 2,783 river km as well as 6,042 km² of estuarine and marine habitat (Figure 16).



Note: Critical habitat is delineated in red.

Figure 16. Map of Gulf Sturgeon Designated Critical Habitat in the Gulf of America (NOAA 2007)

The PBFs essential for the conservation of Gulf Sturgeon include (69 FR 13370):

1. Abundant food items, such as detritus, aquatic insects, worms, and/or mollusks, within riverine habitats for larval and juvenile life stages; and abundant prey items, such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or crustaceans, within estuarine and marine habitats and substrates for sub adult and adult life stages;
2. Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone, or hard clay;
3. Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, sub adult, and/or juveniles, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during fresh water residency and possibly for osmoregulatory functions;
4. A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection,

- courtship, egg fertilization, resting, and staging, and for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging;
5. Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;
 6. Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and
 7. Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g., an unobstructed river or a dammed river that still allows for passage).

Proposed Navy training and testing activities involving the use of explosives overlap designated critical habitat for Gulf sturgeon within one mile of the coastline in the eastern Gulf of America, specifically in the Panama City OPAREA. The Panama City OPAREA lies off the coast of the Florida panhandle and totals approximately 3,000 NM². The vast majority of this OPAREA does not include designated critical habitat and most activities using explosives in this OPAREA are unlikely to occur in nearshore waters where Gulf sturgeon critical habitat has been designated.

According to the Action Proponents' BA, line charge testing is the only activity involving explosives that is likely to be conducted in Gulf sturgeon designated critical habitat. We analyze the effects of this activity on PBF 1, prey resource, here. Line charge testing is proposed to occur four times annually. Other activities using explosives in the Panama City OPAREA are expected to occur greater than 3 NM from shore, outside of designated critical habitat. During line charge testing, surface vessels deploy line charges to test the capability to safely clear surf zone areas for sea-based expeditionary forces. Line charges consist of a 350 ft detonation cord with a series of explosives lined end-to-end in 5 lb. increments. When the charges are detonated, Gulf sturgeon prey in the vicinity are likely to be injured or killed. While the total NEW of a line charge is relatively large, the individual charges are each only 5 lbs. For this reason, the range to injury or mortality for Gulf sturgeon prey around the 350-ft detonation cord will be relatively small and effects to Gulf sturgeon prey will be localized. Effects on prey abundance are also expected to be temporary as following the explosion, unaffected animals in close proximity will likely move into the area that was disturbed by the explosive to utilize the unoccupied habitat. Because reductions in prey abundance will be temporary and localized, this reduces the likelihood that any reduction in prey abundance would occur when Gulf sturgeon are utilizing the habitat. Also important to note is that a limited number of line charges are proposed for use in this area annually (i.e., four total annually). Finally, the Navy will implement mitigation such that line charges will not be used in Gulf sturgeon designated critical habitat from October through March, during the Gulf sturgeon migration season and when the species is most likely to be present (and foraging) in these areas.

In summary, we anticipate reductions in abundance of Gulf sturgeon prey in designated critical habitat from the use of explosives, but these reductions in abundance will be highly localized and

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

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

Safe and unobstructed migratory pathways necessary for passage is PBF 7 (see above) for Gulf sturgeon designated critical habitat. All of the proposed AFTT activities that overlap with Gulf sturgeon critical habitat that involve the physical presence of the Action Proponents and/or the production of noise have the potential to create physical barriers that may affect the passage of Gulf sturgeon. Activities that may create a barrier include the use of vessels, sonar and other transducers, in-water devices, expended military material, and seafloor devices.

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

anticipate that the use of seafloor devices and expended military material would have meaningful effects on the conservation value of Gulf sturgeon critical habitat. Thus, the effects of seafloor devices and expended military material on soft substrate in Gulf sturgeon critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

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

We have also determined that the stressors resulting from the proposed action will not affect the other Gulf sturgeon critical habitat PBFs listed above (e.g., bottom substrate and other conditions in riverine habitats, flow regime, sediment quality, and water quality conditions). These PBFs would either not overlap with AFTT stressors (e.g., PBFs in spawning and early life stage habitats) or there would be no pathway to effects. See Section 4.1.1 (*Stressors Resulting in Effects to Habitat or Prey of ESA-listed Species*) for a discussion of stressors not likely to adversely affect habitat or prey of ESA-listed species, in general.

Therefore, since any potential effects of stressors resulting from the proposed action on the PBFs of Gulf sturgeon critical habitat are insignificant, we conclude that the proposed action may affect, but is not is likely to adversely affect, Gulf sturgeon designated critical habitat.

Atlantic/Caribbean Corals – Designated Critical Habitat

In 2023, critical habitat was designated for five species of Atlantic/Caribbean ESA-listed coral: pillar coral, lobed star coral, mountainous star coral, boulder star coral and rough cactus coral (88 FR 54026 and 89 FR 19511; Figures 17 and 18). Critical habitat for the five Atlantic/Caribbean coral species includes 28 mostly overlapping specific occupied areas within the species' ranges in Florida, Puerto Rico, the USVI, Navassa Island, and the Flower Garden Banks National Marine Sanctuary (FGBNMS), containing physical features essential to the conservation of these species. Critical habitat areas cover approximately 6,500 nm² (16,830 km²) of marine habitat. The designated critical habitat boundaries are defined as all marine waters in the particular depth ranges relative to mean low water of the locations of the critical habitat units for the five species of Atlantic/Caribbean corals. There are five or six specific areas per species within which the individual species' specific areas are largely overlapping. The difference between each of the areas is the particular depth contours used to create the boundaries.

Overlaying the specific areas for each species results in the maximum geographic extent of the areas under consideration for designation, which covers 1.6 to 295 ft (0.5 to 90 m) water depth around all the islands of Puerto Rico, the USVI, and 1.6 to 131.2 ft (0.5 to 40 m) from St. Lucie Inlet, Martin County to Dry Tortugas, Florida.

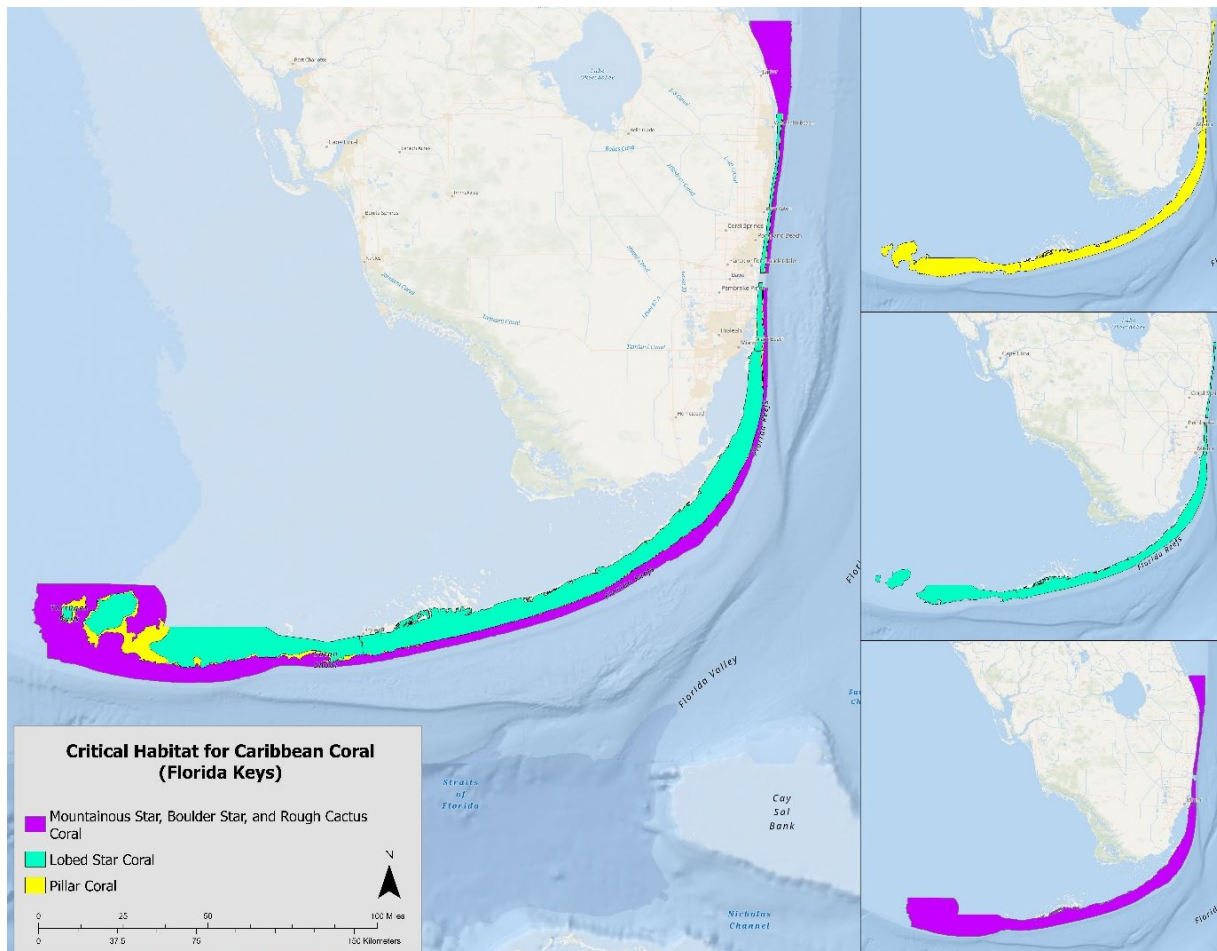


Figure 17. Map Identifying Critical Habitat for Threatened and Endangered Atlantic/Caribbean Corals off Florida

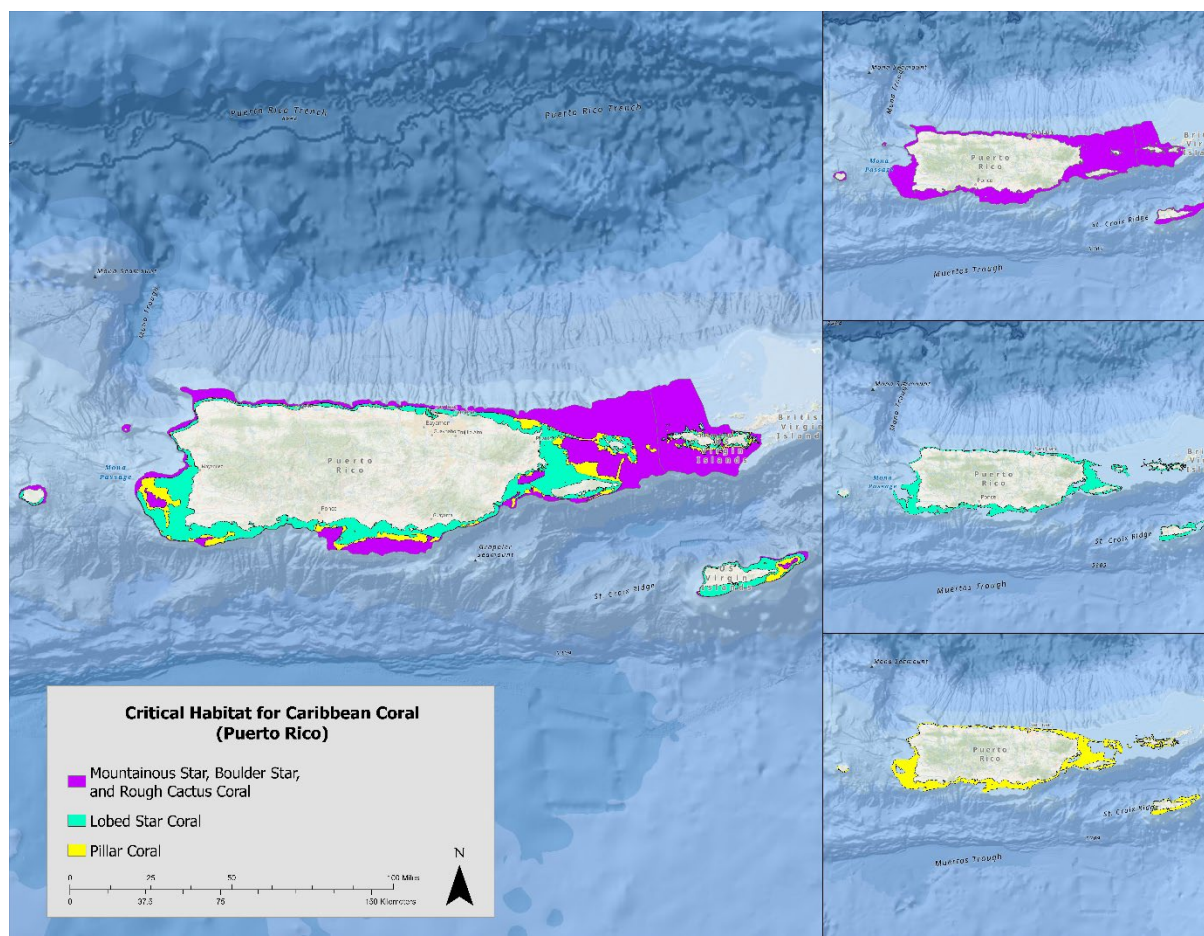


Figure 18. Map Identifying Critical Habitat for Threatened and Endangered Atlantic/Caribbean Corals off Puerto Rico and United States Virgin Islands

Essential Physical and Biological Features

Based on the best scientific information available, NMFS identified the following critical habitat essential physical feature for pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral:

Sites that support the normal function of all life stages of the corals, including reproduction, recruitment, and maturation. These sites are natural, consolidated hard substrate or dead coral skeleton, which is free of algae and sediment at the appropriate scale at the point of larval settlement or fragment reattachment, and the associated water column.

The critical habitat designation also recognized the following attributes of these sites that determine the quality of the area and influence the value of the associated feature to the conservation of the species:

- 1) Substrate with the presence of crevices and holes that provide cryptic habitat, the presence of microbial biofilms, or presence of crustose coralline algae;
- 2) Reefscape with no more than a thin veneer of sediment and low occupancy by fleshy and turf macroalgae;

- 3) Marine water with levels of temperature, aragonite saturation, nutrients, and water clarity that have been observed to support any demographic function; and
- 4) Marine water with levels of anthropogenically-introduced (from humans) chemical contaminants that do not preclude or inhibit any demographic function.

The assessment of potential impacts to coral critical habitat requires careful examination of how military training and testing activities may affect the essential PBFs that support coral survival, reproduction, and habitat functionality. This analysis considers both direct and indirect pathways through which these activities could influence designated critical habitat areas and their associated features. Military activities, particularly those involving explosives or physical disturbance from expended materials, can significantly alter these baseline conditions. The use of explosives in training areas can reduce hard coral structures to rubble, fundamentally altering the substrate characteristics that provide essential settlement surfaces for coral larvae and support existing colonies. The Florida Current, flowing from the Straits of Florida around the Florida Peninsula, creates a potential pathway for material transport that could affect coral populations even when initially deployed outside their typical depth range.

The quality and characteristics of the water column represent crucial biological features within designated critical habitat areas. These features include appropriate levels of temperature, aragonite saturation, nutrients, and water clarity that support coral demographic functions (EPA 2024). Training and testing activities can influence these parameters through several mechanisms. Explosive detonations and associated activities can cause temporary but significant increases in suspended sediments, which may interfere with coral feeding mechanisms and reduce photosynthetic capability of symbiotic algae. Additionally, sediment suspension can alter local water chemistry conditions, potentially affecting the aragonite saturation levels necessary for coral skeleton formation.

The biological features of pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral critical habitat include complex ecological relationships that support coral health and reproduction. These include substrate with the presence of microbial biofilms or presence of crustose coralline algae, and no more than a thin veneer of sediment and low occupancy by fleshy and turf macroalgae. Military activities can disrupt these biological interactions through multiple pathways. Physical damage from explosives or military expended materials can directly eliminate beneficial organisms, while sediment suspension can smother essential biological communities that contribute to coral habitat functionality.

Military activities can introduce various chemical stressors that may affect the quality of coral critical habitat. The release of metals, organic chemicals, and other substances associated with training activities can influence water quality parameters essential for coral survival. These chemical alterations may interact with natural environmental stressors, potentially amplifying negative effects on critical habitat features. For example, increased nutrient loads from disturbed sediments as a result of military explosives can promote algal growth that competes with corals for space and resources.

The impact analysis must consider both immediate and long-term effects on critical habitat features. Most detonations occurring on or near the bottom in the KWRC for training and testing would use explosive charges that are very small (0.1 lb. NEW) or small (5 to 10 lb. NEW). This amount of explosives can create impact craters ranging from 12 to 80 ft² diameter respectively (Navy 2024b), with mortality rates between 50% to 80% in directly affected areas. However, the spatial extent of impacts extends beyond immediate blast zones through secondary effects such as sediment transport and habitat fragmentation. These broader impacts can compromise the functionality of critical habitat features across larger areas, potentially affecting coral recruitment and survival patterns over extended periods.

Notable exemptions from the critical habitat designation for these species include portions of the action area around NAS Key West and portions of the SFOMF Testing Range, totaling approximately 5.5 square miles (mi²). The exclusion area within NAS Key West includes the land and waters generally out to 150 ft (45.7 m) adjacent to the base for a total of approximately 800 in-water acres. The Integrated Natural Resources Management Plan for the base was determined by NMFS to provide a benefit to these ESA-listed coral species found within the in-water area of the base (Navy 2020). Within the KWRC, hard bottom that could provide suitable habitat for coral recruitment represents up to 17.9% of the substrate within the depth range of ESA-listed corals and/or areas within 12 NM of the shoreline (Reed et al. 2014). This translates to approximately 0.0026 km² of potential coral habitat that could be impacted by military explosive/expended materials, out of a total critical habitat area for the five Atlantic/Caribbean coral species of 16,830 km² (Navy 2024c).

Based on the available geographic data and operational parameters, the actual area where AFTT explosive impacts could affect shallow-water coral habitats is extremely limited. The majority of coral reef critical habitat areas either fall outside training and testing ranges or are protected by sanctuary status. Additionally, recent surveys (Navy 2024g) indicate that many areas of potential overlap do not contain ESA-listed coral species. While the total coral reef area within AFTT is substantial, the combination of geographic restrictions, sanctuary protections, and actual species distribution patterns significantly reduces the potential impact to critical habitat throughout AFTT. In addition, to minimize potential impacts to critical habitat features, the Action Proponents will implement comprehensive protective measures through their environmental compliance protocols and mitigation and minimization measures identified in Section 2.3. These measures include geographic restrictions on certain activities near sensitive habitat areas and the use of the PMAP to identify required environmental protections. Such measures help maintain the functionality of critical habitat features by minimizing direct physical impacts and reducing secondary effects on water quality and biological communities. Therefore, given the very small area of overlap between AFTT shallow-water (< 90 m) explosive activities and designated critical habitat, and the mitigation measures in place to further minimize impacts, we find it extremely unlikely that the PBFs of pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral critical habitat will be adversely affected by any of the stressors associated with AFTT explosive activities, including physical disturbance, expended materials, and sedimentation. As discussed in Section 4.1.1, we also find that any effects from secondary

(or indirect) stressors resulting from the AFTT explosive activities (e.g., explosive byproducts, metals, and chemicals) are unlikely to have measureable impacts on coral critical habitat. For the other stressors resulting from the proposed action (Section 2.4), we find there is either no pathway to effects, or there is no spatial overlap between these stressors and pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral critical habitat.

In summary, the effects of stressors resulting from the proposed action on the PBFs of pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral critical habitat are either discountable (in the case of physical disturbance effects from explosives, expended materials, or sedimentation) or insignificant (in the case of secondary water quality stressors such as explosive byproducts, metals, and chemicals). Therefore, the proposed action is not likely to adversely affect pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral designated critical habitat.

Elkhorn and Staghorn Corals – Designated Critical Habitat

Critical habitat was designated for elkhorn coral and staghorn coral in 2008 (73 FR 72210; Figures 19 and 20). Designated critical habitat includes Florida (portions of Southeastern Florida and the Florida Keys), Puerto Rico, St. Thomas/St. John, and St. Croix.



Figure 19. Map Identifying Critical Habitat for Elkhorn and Staghorn Corals off Florida



Figure 20. Map Identifying Critical Habitat for Elkhorn and Staghorn Corals off Puerto Rico and United States Virgin Islands

Essential Physical and Biological Features

The features essential to the conservation of elkhorn and staghorn corals are substrate of suitable quality and availability in-water depths from the mean high water line to 98 ft (30 m) to allow for successful sexual and asexual reproduction. Successful sexual and asexual reproduction includes flourishing larval settlement, recruitment, and reattachment of coral fragments. “Substrate of suitable quality and availability” means consolidated hard bottom or dead coral skeletons free from fleshy macroalgae or turf algae and sediment cover.

These features can be found unevenly dispersed throughout the critical habitat units, interspersed with natural areas of loose sediment, fleshy or turf macroalgae covered hard substrate. The Florida unit comprises approximately 1,329 mi² (3,442 km²) of marine habitat; Puerto Rico approximately 1,383 mi² (3,581 km²); St. Thomas/St. John approximately 121 mi² (313 km²); and St. Croix approximately 126 mi² (326 km²). Thus, the total area covered by the designation is approximately 2,959 mi² (7,664 km²). Within these areas, the substrate composition and structural integrity are fundamental physical features essential for coral reproduction, recruitment, growth, and maturation.

The assessment of potential impacts to coral critical habitat requires careful examination of how military training and testing activities may affect the essential PBFs that support coral survival, reproduction, and habitat functionality. This analysis considers both direct and indirect pathways through which these activities could influence designated critical habitat areas and their associated features. Military activities, particularly those involving explosives or physical disturbance from expended materials, can significantly alter these baseline conditions. The use of explosives in training areas can reduce hard coral structures to rubble, fundamentally altering the

substrate characteristics that provide essential settlement surfaces for coral larvae and support existing colonies. The Florida Current, flowing from the Straits of Florida around the Florida Peninsula, creates a potential pathway for material transport that could affect coral populations even when initially deployed outside their typical depth range.

The biological feature of elkhorn and staghorn coral critical habitat includes complex ecological relationships that support coral health and reproduction. This feature includes natural consolidated hard substrate or dead coral skeleton that is free from fleshy or turf macroalgae cover and sediment cover. Military activities can disrupt these biological interactions through multiple pathways. Physical damage from explosives or military expended materials can directly eliminate beneficial organisms that help maintain this feature, while sediment suspension can smother essential biological communities that contribute to coral habitat functionality. Military activities can also introduce various chemical stressors that may affect the quality of coral critical habitat. The release of metals, organic chemicals, and other substances associated with training activities can influence water quality parameters essential for coral survival. These chemical alterations may interact with natural environmental stressors, potentially amplifying negative effects on critical habitat features. For example, increased nutrient loads from disturbed sediments as a result of military explosives can promote algal growth that competes with corals for space and resources.

The impact analysis must consider both immediate and long-term effects on critical habitat features. Most detonations occurring on or near the bottom in the KWRC for training and testing would use explosive charges that are very small (0.1 lb. NEW) or small (5 to 10 lb. NEW). This amount of explosives can create impact craters ranging from 12 to 80 ft² diameter respectively (Navy 2024b), with mortality rates between 50% to 80% in directly affected areas. However, the spatial extent of impacts extends beyond immediate blast zones through secondary effects such as sediment transport and habitat fragmentation. These broader impacts can compromise the functionality of critical habitat features across larger areas, potentially affecting coral recruitment and survival patterns over extended periods.

Notable exemptions from the critical habitat designation for these species include portions of the action area around NAS Key West and portions of the SFOMF Testing Range, totaling approximately 5.5 mi². The exclusion area within NAS Key West includes the land and waters generally out to 150 ft (45.7 m) adjacent to the base for a total of approximately 800 in-water acres. The Integrated Natural Resources Management Plan for the base was determined by NMFS to provide a benefit to these ESA-listed coral species found within the in-water area of the base (Navy 2020). Within the KWRC, hard bottom that could provide suitable habitat for coral recruitment represents up to 17.9% of the substrate within the depth range of ESA-listed corals and/or areas within 12 NM of the shoreline (Reed et al. 2014). This translates to approximately 0.0026 km² of potential coral habitat that could be impacted by military explosive/expended materials, out of the total area within the Florida unit of critical habitat for elkhorn and staghorn coral of 3,442 km² (Navy 2024c).

Based on the available geographic data and operational parameters, the actual area where AFTT explosive impacts could affect shallow-water coral habitats is extremely limited. The majority of

coral reef critical habitat areas either fall outside training and testing ranges or are protected by sanctuary status. Additionally, recent surveys (Navy 2024g) indicate that many areas of potential overlap do not contain ESA-listed coral species. While the total coral reef area within AFTT is substantial, the combination of geographic restrictions, sanctuary protections, and actual species distribution patterns significantly reduces the potential impact to critical habitat throughout AFTT. In addition, to minimize potential impacts to critical habitat features, the Action Proponents will implement comprehensive protective measures through their environmental compliance protocols and mitigation and minimization measures identified in Section 2.3. These measures include geographic restrictions on certain activities near sensitive habitat areas and the use of the PMAP to identify required environmental protections. Such measures help maintain the functionality of critical habitat features by minimizing direct physical impacts and reducing secondary effects on water quality and biological communities. Therefore, given the very small area of overlap between AFTT shallow-water (< 30 m) explosive activities and designated critical habitat, and the mitigation measures in place to further minimize impacts, we find it extremely unlikely that the PBF (i.e., substrate of suitable quality and availability) of elkhorn or staghorn coral critical habitat will be adversely affected by any of the stressors associated with AFTT explosive activities, including physical disturbance, expended materials, and sedimentation. For the other stressors resulting from the proposed action (Section 2.4), we find there is either no pathway to effects, or there is no spatial overlap between these stressors and elkhorn and staghorn critical habitat.

In summary, the potential effects of stressors resulting from the proposed action on the PBFs of elkhorn and staghorn critical habitat are discountable. Therefore, the proposed action is not likely to adversely affect elkhorn or staghorn designated critical habitat.

4.2 Status of the Species Likely to be Adversely Affected

The remainder of this opinion examines the status of each species that is likely to be adversely affected by the proposed action. The status is an assessment of the abundance, recent trends in abundance, survival rates, life stages present, limiting factors, and sub-lethal or indirect changes in population trends such as inter-breeding period, shifts in distribution or habitat use, and shifts in predator distribution that contribute to the extinction risk that the listed species face. The status of each species below is described in terms of life history, threats, population dynamics, and recovery planning.

The information used for each species is based on parameters considered in documents such as status reviews, recovery plans, and listing decisions, and based on the best available scientific and commercial information. This section establishes a reference to the condition of the species' likelihood of both survival and recovery in terms of "reproduction, numbers, or distribution" as described in 50 CFR §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on the NMFS OPR web site (<https://www.fisheries.noaa.gov/species-directory/threatened-endangered>).

4.2.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans. The blue whale was originally listed as endangered throughout its range under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained listed as endangered after the passage of the ESA in 1973.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of 10 to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between 5 and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms daily. Feeding aggregations are often found at the continental shelf edge, where up-welling produces concentrations of krill at depths of 90 to 120 m.

Population Dynamics

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

The 2020 blue whale recovery plan identified the following nine management units: North Atlantic; Eastern North Pacific; Western/Central North Pacific; Northern Indian Ocean; Madagascar; Western Australia/Indonesia; New Zealand; Chilean; and Antarctic. Although blue whales in the North Atlantic are considered a single management unit in the NMFS species recovery plan, the question of whether eastern and western whales in the North Atlantic constitute one population or two is unresolved (NMFS 2020b).

The current global population size is uncertain, but estimated to be in the range of 5,000 to 15,000 mature individuals (NMFS 2020b). There is also some uncertainty behind the abundance estimates for blue whales in the North Atlantic due to inherent uncertainties in the historical estimates regarding sampling design and data collection methodologies (NMFS 2020a). From 1980 to the summer of 2008, a total of 402 blue whales were photo-identified, mainly in the St. Lawrence estuary and northwestern Gulf of St. Lawrence (Ramp et al. 2013). Ramp et al. (2006) estimated the survival rate for this population of 0.975.

Little is known about the population size of blue whales outside of the Gulf of St. Lawrence area. An abundance estimate of 39 (CV=0.64) blue whales was generated from a shipboard and aerial survey covering an area from Virginia through the lower Bay of Fundy during the summer of 2016 (Hayes et al. 2020). Because this estimate is only for the U.S. portion of the population, the estimate of 402 from the Gulf of St. Lawrence is considered the more robust abundance estimate for the Western North Atlantic stock. There are insufficient data to determine population trends for this species (Hayes et al. 2020).

Five subspecies of blue whale are currently recognized: *B. m. musculus* is the northern blue whale (North Atlantic and North Pacific Oceans); *B. m. intermedia* is the Antarctic blue whale; *B. m. breviceuda* colloquially known as the “pygmy” blue whale; and *B. m. indica* is the northern Indian Ocean blue whale (NMFS 2020b). Only a few studies have focused on genetic diversity of blue whale populations. Jossey et al. (2024) used whole genome sequencing to study population genetics of North Atlantic blue whales. Present-day and historical samples (earliest from 1876) from the Atlantic and Antarctic Oceans were included to understand the impact of whaling on the genetic diversity of this species. Their results showed low but statistically significant population structuring, high genetic diversity, and likely asymmetric west to east gene flow in North Atlantic blue whales. Data from Australia indicates that populations in this region experienced a recent genetic bottleneck, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). Consistent with this, data from Antarctica also demonstrate this bottleneck but high haplotype diversity, which may be a consequence of the recent timing of the bottleneck and blue whales long lifespan (Sremba et al. 2012).

In general, blue whale distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters off eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. The distribution of the blue whale in the western North Atlantic generally extends from the Arctic to at least mid-latitude waters (Figure 21). Blue whales are considered rare in U.S. EEZ waters of the northwestern Atlantic Ocean (Zoidis et al. 2021). The Mid-Atlantic region may represent the current southern limit of its feeding range (CETAP 1982; Wenzel et al. 1988). Recently, two blue whale sightings were noted off the coast of Virginia in 2018 and 2019 (Engelhaupt et al. 2020).

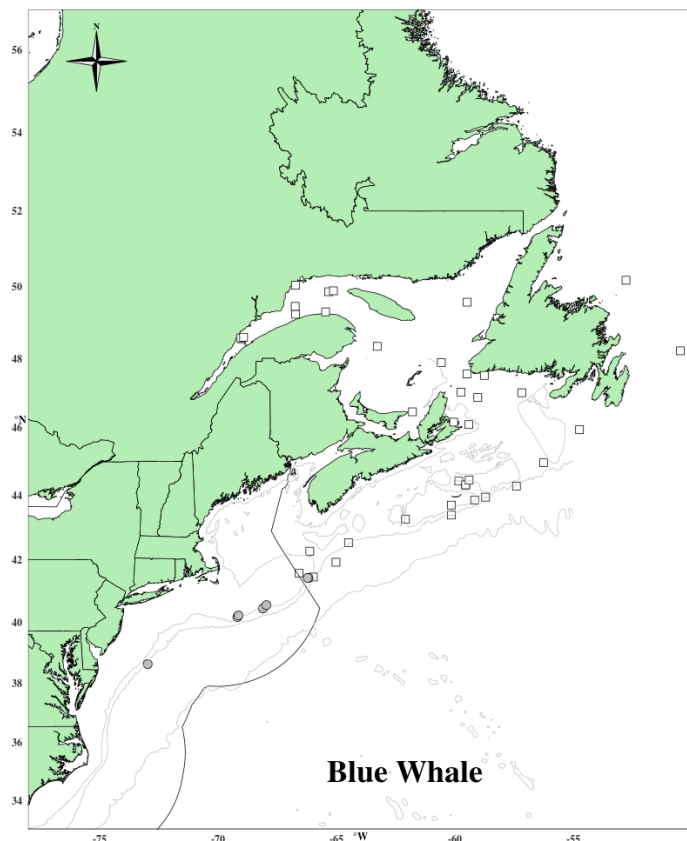


Figure 21. Distribution of Blue Whale Sightings off the Atlantic Coast from Shipboard (circles) and Aerial (squares) Summer Surveys between 1998 and 2016 (Hayes et al. 2020) In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a “resident” population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies (*B. m. intermedia* and *B. m. breviceauda*) seem to be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the “Antarctic Convergence” (located between 48°S and 61°S latitude) and close to the ice edge. The subspecies *B. m. breviceauda* is typically distributed north of the Antarctic Convergence.

Vocalizations and Hearing

Blue whale vocalizations tend to be low frequency (less than 100 Hz) signals (Thomson and Richardson 1995), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (McDonald et al. 1995; Ketten 1998; McDonald et al. 2001; Mellinger and Clark 2003). As with other baleen whales, blue whale vocalization function is unknown, although numerous hypotheses exist including maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources (Payne and Webb. 1971; Thompson et al. 1992; Edds-Walton 1997; Oleson et al. 2007b).

Vocalizations are predominantly songs and calls. Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971; McDonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Payne and Mcvay 1971; Mellinger and Clark 2003). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (McDonald et al. 2001; Oleson et al. 2007a). Blue whale calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (20 to 80 Hz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 μ Pa at 1 m (Cummings and Thompson 1971; Aburto et al. 1997; Ketten 1998; McDonald et al. 2001; Clark and Gagnon 2004; Berchok et al. 2006; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported reduced vocalization during daytime foraging, followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 m whales), while deeper diving whales (greater than 50 m) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (Thompson et al. 1996; McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005), some variability appears to exist among different geographic areas (Rivers 1997). Blue whale sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark 2003; Berchok et al. 2006; Samaran et al. 2010).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Richardson et al. 1995a; Ketten 1997). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001; Stafford and Moore 2005; Oleson et al. 2007c). In terms of functional hearing capability, blue whales are included in the low frequency¹⁰ cetacean group, which have a hearing range of 7 Hz to 36 kHz (NMFS 2024g).

Status

Due largely to commercial whaling during the 19th and 20th centuries, blue whale populations declined, with over 380,000 blue whales taken between 1868 and 1978, predominantly from Antarctic waters (NMFS 2020b). In the North Atlantic Ocean, at least 11,000 blue whales were harvested from the late 19th to mid-20th centuries. The global mature population size in 1926 was around 140,000. The current global population size is estimated to be in the range of 5,000 to 15,000 mature individuals (NMFS 2020b). This corresponds to a reduction of 89% to 97%

¹⁰ As discussed below (Section 6.1.1.3.2), for the Phase IV NAEMO auditory impacts analysis blue whales are included in the very-low frequency cetacean hearing group.

compared to the 1926 global population estimate (Cooke 2018). Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, entanglement in marine debris and fishing gear, pollution, harassment due to whale watching, anthropogenic noise, and reduced prey abundance and habitat degradation due to changing environmental conditions and ecosystem changes. Although still depleted compared to historical abundance, blue whale populations around the world show signs of growth (NMFS 2020b). This suggests that the species appears to be somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals and objectives to recover blue whale populations. The two main recovery objectives from the 1998 blue whale recovery plan (NMFS 1998b) were to: 1) increase blue whale resiliency and ensure geographic and ecological representation by achieving sufficient and viable populations in all ocean basins and in each recognized subspecies, and 2) increase blue whale resiliency by managing or eliminating significant anthropogenic threats. Threats to blue whales are discussed in further detail in the environmental baseline section of this opinion (Section 5). Specific objectives of the 1998 plan included:

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

In 2020, NMFS published the first revision to the 1998 plan (NMFS 2020b). Key elements of the recovery strategy laid out in the revised plan include: 1) maintaining the international ban on commercial hunting, 2) improving our understanding of how potential threats may be limiting blue whale recovery and implementing actions where populations may be vulnerable, and 3) outlining a research strategy to obtain data necessary to inform estimation of population abundance and trends. Once the populations and their threats are more fully understood, the blue whale recovery plan will be modified to include actions to minimize any threats that are determined to be limiting recovery.

The 2020 revision to the blue whale recovery plan includes specific down listing/delisting criteria for each of the nine management units. Recovery of all nine management units is important for achieving geographic and ecological representation of blue whales in the world's oceans, and to ensure conservation of the breadth of genetic variability (NMFS 1998b). One criterion for all units is that anthropogenic threats have been identified and demonstrably minimized; i.e., there is information indicating they are not contributing to the species being in danger of extinction (within the foreseeable future, for delisting) throughout all or a significant portion of its range. The following specific downlisting/delisting criteria are specified for the North Atlantic management unit, which occurs within the action area: minimum abundance of 2,000 for downlisting and 2,500 for delisting; stable or increasing abundance for downlisting and increasing abundance trend for delisting (over the most recent 30-year period assessed) (NMFS 2020b).

4.2.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans. The fin whale was originally listed as endangered throughout its range under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained listed after the passage of the ESA in 1973.

Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. The generation time may be as long as 25.9 years (NMFS 2019c).

Fin whales mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice.

Population Dynamics

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

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters. The best available current abundance estimate for fin whales in the Western North Atlantic stock from Florida to Newfoundland/Labrador is 6,802 (CV=0.24) (Hayes et al. 2023). A trend analysis has not been conducted for the Western North Atlantic stock due to the relatively imprecise abundance estimates and variable survey design (Hayes et al. 2023).

There are three stocks in U.S. Pacific Ocean waters: Northeast Pacific (minimum 1,368 individuals), Hawaii (approximately 58 individuals, $N_{\min}=27$) and California/Oregon/Washington (approximately 9,029 individuals, $N_{\min}=8,127$) (Nadeem et al. 2016). The International Whaling Commission (IWC) also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). The estimated annual growth rate is 4.8% for the Northeast Pacific stock, and a stable population abundance for the California/Oregon/Washington stock (Nadeem et al. 2016). Overall population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Three subspecies of fin whale are currently recognized: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachonica* (a pygmy form) in the Southern Hemisphere. Archer et al. (2013) examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean. Genetic, acoustic, and isotope analyses indicate there may be some population differentiation within the North Atlantic, and there is acknowledged differentiation between the North Atlantic and Mediterranean. Generally speaking, haplotype diversity was found to be high both within and across ocean basins. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

Fin whales are highly migratory and exhibit complex movement patterns. Movements can be either inshore/offshore or north/south (NMFS 2019c). Fin whales occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally. Movements of individuals in a given year may vary according to their energetic and reproductive condition, climatic variables, and other factors. The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

Fin whales are common in waters of the U.S. Atlantic EEZ, principally from Cape Hatteras northward, and have been sighted in every season throughout much of the U.S. EEZ north of 30° N (Hayes et al. 2023). Zoidis et al (2021) reported the highest sighting rate for fin whales in the New York Bight region in the summer (3.44 whales/1,000 km), followed by spring (1.13 whales/1,000 km), winter (0.90 whales/1,000 km), and fall (0.53 whales/1,000 km). New England and Gulf of St. Lawrence waters represent major feeding grounds for North Atlantic fin whales. It is likely that fin whales occurring in the U.S. Atlantic EEZ undergo migrations into Canadian waters, open-ocean areas, and perhaps even subtropical or tropical regions (Edwards et al. 2015).

Vocalizations and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Watkins 1981; Watkins et al. 1987; Edds 1988; Thompson et al. 1992). Typical vocalizations are long, patterned pulses of short duration (0.5 to 2 seconds) in the 18 to 35 Hz range, but only males are known to produce these (Patterson and Hamilton 1964; Clark et al. 2002). The most typically recorded call is a 20 Hz pulse lasting about one second, and reaching source levels of 189 ± 4 dB re: 1 μ Pa at 1 m (Watkins 1981; Watkins et al. 1987; Edds 1988; Richardson et al. 1995a; Charif et al. 2002; Clark et al. 2002; Sirovic et al. 2007). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995a) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Watkins 1981; Edds 1988; Cummings and Thompson 1994). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 μ Pa at 1 m (as compiled by Erbe 2002; see also Clark and Gagnon 2004).

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

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995a; Ketten 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 to 2 kHz range. In terms of functional hearing capability, fin whales belong to the low-frequency¹¹ group, which have a hearing range of 7 Hz to 36 kHz (NMFS 2024g).

¹¹ As discussed below (Section 6.1.1), for the Phase IV NAEMO auditory impacts analysis fin whales are included in the very-low frequency cetacean hearing group.

Status

The fin whale is endangered as a result of past commercial whaling. Fin whale populations declined, due largely from direct harvest, by more than 70% from 1929-2007 (NMFS 2019c). A small number of fin whales may be killed under “aboriginal subsistence whaling” in Greenland, under Japan’s scientific whaling program, and Iceland’s formal objection to the International Whaling Commission’s ban on commercial whaling. Besides direct harvest, all other threats in the fin whale recovery plan were ‘low’, ‘unknown’, or ‘unknown, but potentially high’ in terms of relative impact to recovery (NMFS 2010b). The two threats that were categorized as ‘unknown, but potentially high’ were ship strikes and loss of prey base due to changing environmental conditions and ecosystem change or shifts in habitat.

Overall species abundance is in the tens of thousands distributed across major ocean basins and hemispheres. This level of abundance and extent of distribution indicates that fin whales have a low probability of experiencing the deleterious effects of small population size such as depensatory processes and random biological and/or environmental variation (NMFS 2019c). The increasing trend for the large central North Atlantic population and increasing populations in the North Pacific indicate that reproduction is exceeding mortality (NMFS 2019c). NMFS is currently considering downlisting the fin whale from endangered to threatened status based on the latest 5-year status review (NMFS 2019c) and information since that review was published, and the fin whale recovery plan criteria.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed the following goals to recover fin whale populations (NMFS 2010b):

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

Threats to fin whales are discussed in further detail in the environmental baseline section of this opinion (Section 5).

Downlisting criteria for fin whales include:

- Factors that may limit population growth (i.e., those that are identified as either high, medium, or unknown impact to recovery) have been identified and are being or have been addressed to the extent that they allow for continued growth of populations in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere).
- The population in each ocean basin satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) and has at least 500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males) (NMFS 2010b).

4.2.3 Rice's Whale

Rice's whales were initially listed as endangered under the name Gulf of Mexico Bryde's whale (*Balaenoptera edeni*) on April 15, 2019 (84 FR 15446). On August 23, 2021, NMFS published a final rule that revised the listing of Rice's whales under the ESA to reflect the change in the scientifically accepted taxonomy and nomenclature of this species (86 FR 47022).

Life History

Since limited information is available on the life history of Rice's whales, this section also includes information on the closely related Bryde's whale, in general.

Length measurements for Rice's whales, based on a small sample size, range from about 15 to 42 ft. The life expectancy of Rice's whales is unknown. The sex ratio determined for 32 individual whales stranded or biopsied from the northern Gulf of America was 18 females and 14 males, which is not significantly different from a 50:50 ratio (Rosel et al. 2021). Maze-Foley and Mullin (2006) found Rice's whales to have a mean group size of 2 (range 1-5, n = 14), similar to reported group sizes for Bryde's whales (Wade and Gerrodette 1993).

Age of sexual maturity is not known for Rice's whales specifically. However, based on information for Bryde's whales, this species is thought to become sexually mature between 8 and 13 years of age and reproduce every two to three years (Taylor et al. 2007; NMFS 2023d). Taylor et al. (2007) estimated a generation length for Bryde's whales of 18.4 years, based primarily on life history parameters derived from Japanese whaling operations (Rosel 2016). Bryde's whale populations typically have a gestation period of 11 to 12 months, and give birth to a single calf, which is nursed for 6 to 12 months. Rice's whales are likely breeding in the Gulf of America, but the precise location (or locations) used for reproductive behaviors is unknown. Peak breeding and calving probably occurs in the fall. In October 2009, a dead, lactating female whale was found in Tampa Bay, with internal injuries consistent with blunt force trauma likely caused by a vessel strike (NMFS 2023d).

Rice's whales, unlike other baleen whales, are not known to make long foraging migrations (Figueiredo et al. 2014). No direct information on the foraging ecology of Rice's whales exists. Surface feeding has never been observed, and, as a result, fish scales and tissue remains collected from Rice's whale feeding activity are not available (NMFS 2023d). Rice's whales exhibit a typical diel dive pattern, with deep foraging dives (>200 m) in the daytime, and shallow dives at night. In September 2015, a female Rice's whale was tagged with an acoustic and kinematic data-logging tag in the De Soto Canyon (Soldevilla et al. 2017). Over the nearly three day tagging period, the whale spent 47% of its time within 15 m of the surface during the day, and 88% of its time within 15 m of the surface during the night (Soldevilla et al. 2017). Kok et al. (2023) attached suction cup tags to two Rice's whales to collect information on their diving kinematics and foraging behavior. The tagged whales primarily exhibited lunge-feeding near the sea bottom and to a lesser extent in the water-column and at the sea surface. The median lunge rate of one lunge per dive of both animals was much lower than expected based on comparative research on other lunge-feeding baleen whales, and may be associated with foraging on fish instead of krill or may be an indication of different foraging conditions. Both animals spent

extended periods of the night near the sea surface, increasing the risk for ship strike (Kok et al. 2023).

Based on trawl surveys, Kiszka et al. (2023) inferred that prey items most readily available to Rice's whale include Atlantic pearlside (*Maurolicus weitzmani*), silver-rag driftfish (*Ariomma bondi*), Dumeril's lanternfish (*Diaphus dumerilii*), and longfin inshore squid (*Doryteuthis pealeii*). Stable isotope analysis from biopsy samples of whales indicate that silver-rag driftfish were the primary prey item for Rice's whales, despite the much lower relative abundance of this prey species compared to others. Silver-rag driftfish were found to have a higher energy content than the other prey species analyzed. Because these deep foraging dives require significant expenditures of energy, Rice's whales likely need high quality prey to meet their energetic requirements (NMFS 2023d). Overall, the results from Kiszka et al. (2023) suggest that Rice's whales are selective predators, preferentially targeting schooling demersal and vertically migrating prey with the highest energy content (NMFS 2023d).

Population Dynamics

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

Data from aerial and vessel-based line-transect surveys conducted in the northern Gulf of America from 2017-2018 have been used to estimate abundance. The current best abundance estimate for the Rice's whale is 51 animals, with a confidence interval of 20 to 130 whales (Garrison et al. 2020) and a minimum population estimate of 34 (NMFS 2021f). Given the very small population size, available information is insufficient to effectively monitor trends in Rice's whale abundance over time.

Genetic diversity within the Rice's whale population is very low. Genetic analysis of Rice's whale samples found only two mitochondrial DNA control region haplotypes in the first 375 base pairs of the control region (compared to five haplotypes for North Atlantic right whales and 51 in fin whales across the same control region sequence) (Rosel and Wilcox 2014).

Examination of 42 nuclear microsatellite loci found that 25 (60%) were monomorphic, meaning no genetic variability was seen for the 21 Rice's whales sampled (Rosel 2016).

Based on sighting and stranding data collected from 1992 to 2019, Rosel et al. (2021) reported that the Rice's whale core distribution area (green area in Figure 22) is in the northeastern Gulf of America within a depth range from 100 to 400 m. This area is characterized by seasonal advection of low salinity, high productivity surface waters (i.e., waters with high production of organic matter by planktonic plants), leading to persistent up-welling driven by both winds and interactions with the loop current (Farmer et al. 2022b).

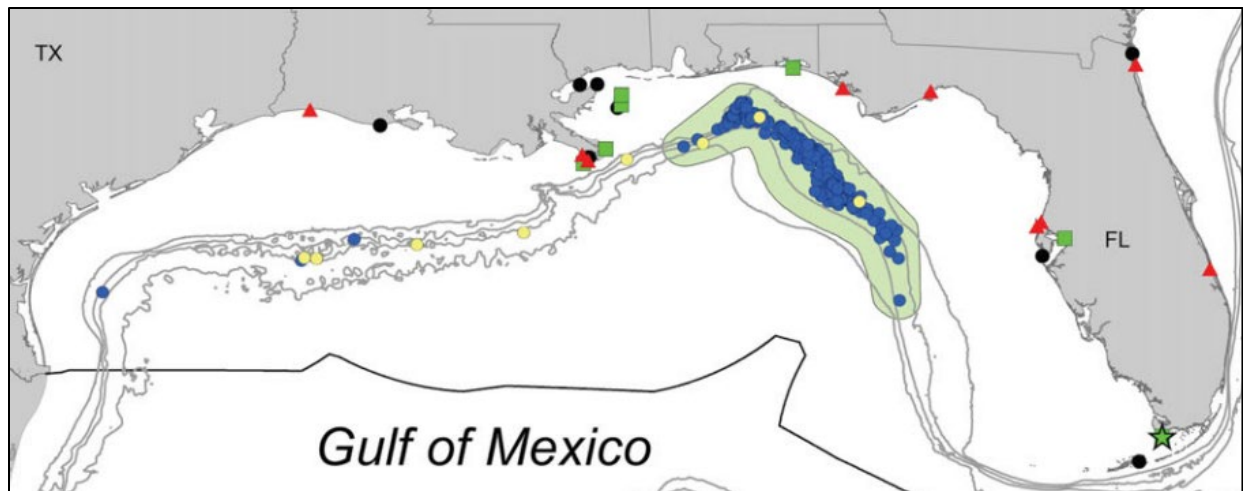


Figure 22. Distribution of Sightings and Strandings of Bryde's-like Whales in the Gulf of America and Atlantic U.S. EEZ from 1992 to 2019 (Rosel et al. 2021)

Two Bryde's-like whales were sighted during a NMFS survey in the western Gulf in the early 1990s (Rosel et al. 2021), prior to the species being renamed as Rice's whale, and there was a confirmed Rice's whale sighting in the western Gulf of America off the central Texas coast at a 225 m water depth in 2017 (Rosel et al. 2021; NMFS 2023d). Data from passive acoustic monitoring revealed long-moan whale calls along the northwestern Gulf of America shelf break that were determined to share distinctive and similar features with Rice's whale calls in the eastern Gulf of America, which provides additional evidence for the occurrence of Rice's whales over a broader distribution in the Gulf of America than previously understood (Soldevilla et al. 2022). At least one call was detected in every month of the year at the western sites, which suggests year-round use of the western habitat area (NMFS 2023d). On April 11, 2024, NOAA Fisheries scientists observed two Rice's whales 55 NM off the coast of Corpus Christi, Texas (approximately 224 m deep water) during an aerial survey in the western Gulf of America. In August 2024, Southeast Fisheries Science Center (SEFSC) biologists also photographed two separate sightings of Rice's whales during a vessel survey offshore of Louisiana in the west-central Gulf of America near the Flower Gardens Banks National Marine Sanctuary (NMFS 2024b). The first sighting was a single whale in approximately 210 m water depth; the second sighting was two whales in approximately 225 m water depth.

Garrison et al. (2024b) developed a density surface model to predict Rice's whale distribution in the Gulf of America based on bathymetric and oceanographic features (Figure 23). The higher density of Rice's whales in the core distribution area appeared to be explained by higher summer chlorophyll-a concentrations. The model predicted additional suitable Rice's whale habitat outside the core distribution area in the northeastern Gulf of America, generally throughout the Gulf of America within 100 and 400 m depth. The model also suggests additional habitat outside of U.S. waters in the southern Gulf of America may be suitable for Rice's whales. The model also predicted seasonal density differences (Figure 24), most notably higher densities in the core area.

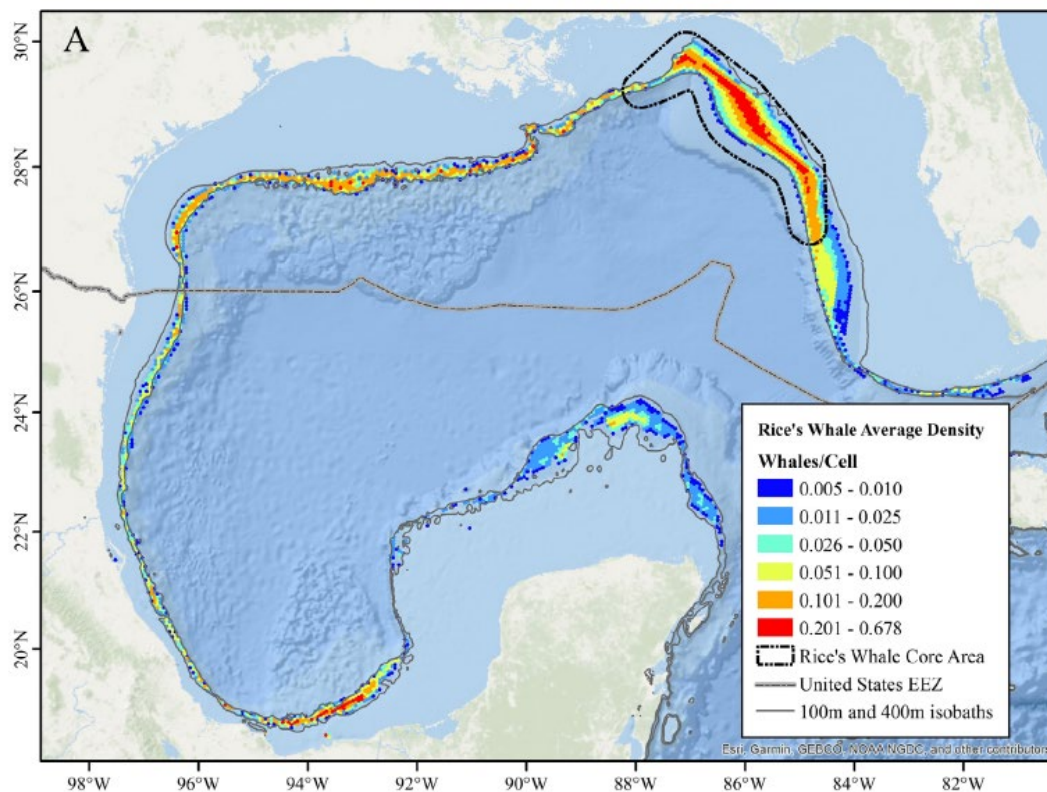


Figure 23. Predicted Average Rice's Whale Density (whales per 40 km², grid cell area) (Garrison et al. 2024b)

The best available information on the species' movement patterns suggests that the Rice's whale is a year-round resident of the Gulf of America (NMFS 2023d). Although the primary species range is within the Gulf of America, 'extralimital' records have been reported along the southeastern coast of the U.S. (Rosel et al. 2021). (Brownell Jr et al. 2024) reviewed historical stranding records of medium-sized baleen whales from the U.S. Western Atlantic and Northern Gulf of America between 1919 and 2023. Of the 12 confirmed Rice's whales strandings records, eight were collected from locations in the Gulf of America, and four from locations along the U.S. eastern seaboard (Florida and Virginia). Three of the four collected along the U.S. eastern seaboard stranded alive or fresh dead, indicating the occurrence of these whales along the Atlantic coast, rather than the drift of the carcasses from the Gulf of America and north along the Gulf Stream. However, no NMFS marine mammal vessel or aerial surveys from 1992 through

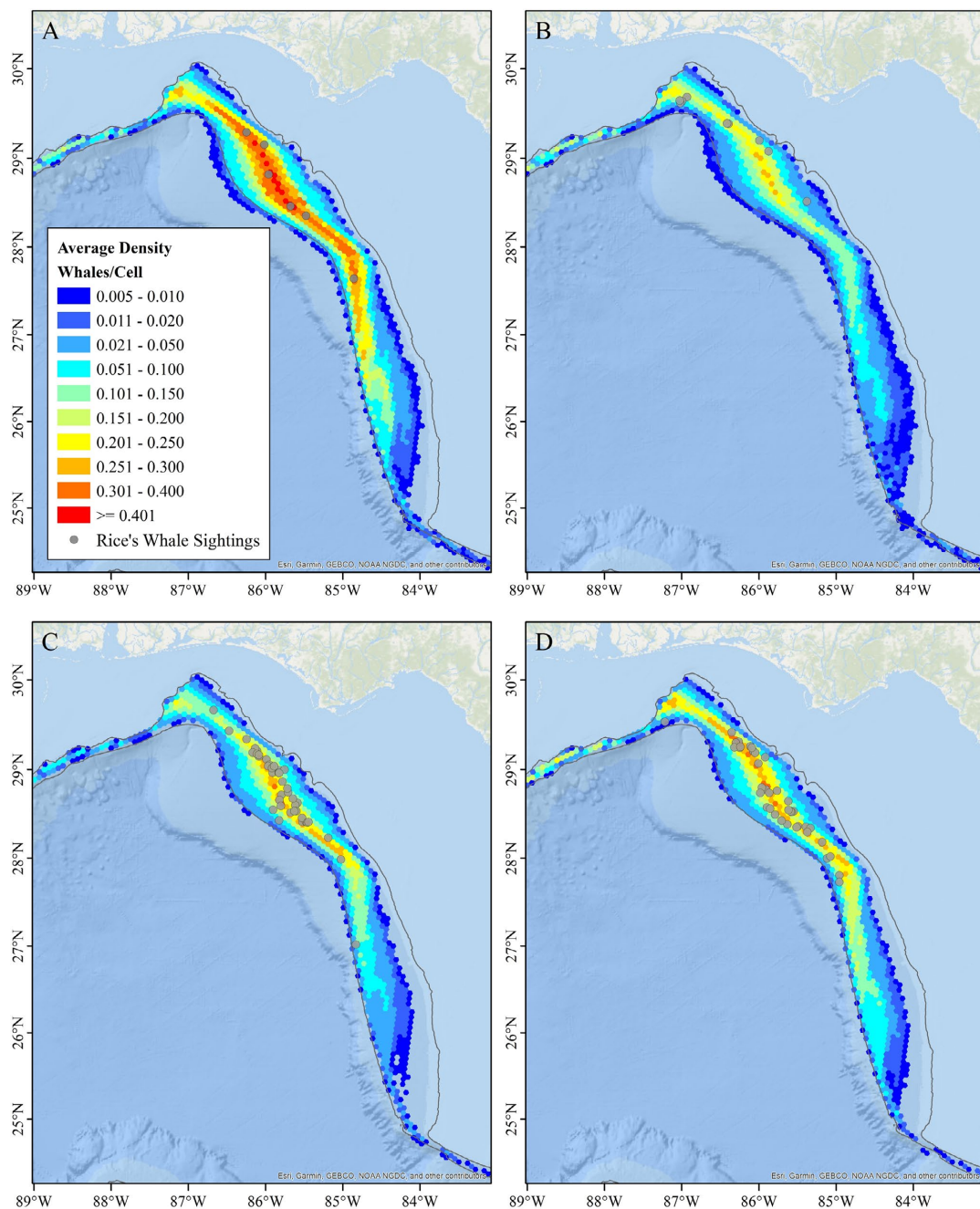


Figure 24. Seasonal Rice's Whale Predicted Density (whales per 40 km², grid cell area) Reflecting Average Environmental Conditions in each Season from 2015–2019 (Garrison et al. 2024b)

2019 have recorded a confirmed sighting of Rice's whales (or any type of Bryde's whale) and there have been no acoustic detections along the U.S. eastern seaboard (Rosel et al. 2021). This suggests that the historical strandings along the U.S. Atlantic may have been extralimital strays from the Gulf of America during winter months.

Vocalization and Hearing

Rice's whales produce highly stereotyped call types, including long-moans, tonal-sequence calls, and pulsed downsweep sequences (Farmer et al. 2022b). The northeastern long-moan call type in the species core habitat area is a long-duration frequency-downswept call with an average initial frequency of 150 Hz, center frequency of 107 Hz, and duration of 22 seconds (Rice et al. 2014). Variants of this call type have been recorded in the northwestern portion of the Gulf of America (Farmer et al. 2022b).

Direct studies of Rice's whale hearing have not been conducted but it is assumed that they can hear the same frequencies that they produce and are likely most sensitive to this frequency range (Richardson et al. 1995a; Ketten 1997). This suggests Rice's whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, Rice's whales belong to the low-frequency group, which have a hearing range of 7 Hz to 36 kHz (NOAA 2016; NMFS 2024g).

Status

Historically, commercial whaling did occur in the Gulf of America, but the area was not considered prime whaling grounds. Commercial whalers did not specifically target Rice's whales, but the "finback whales" which were caught between the mid-1700s and late 1800s were likely Rice's whales (Reeves et al. 2011). The Rice's whale status review identified 27 possible threats, with the following four being the most significant: (1) sound, (2) vessel collisions; (3) energy exploration; and (4) oil spills and oil spill response (Rosel 2016). Noise from shipping traffic and seismic surveys in the region may impact Rice's whales' ability to communicate. Vessel traffic from commercial shipping and the oil and gas industry also poses a risk of vessel strike for Rice's whales. Curiosity around vessels, documented injuries consistent with vessel strikes, and documented behavior near the surface for a considerable amount of time illustrate the anthropogenic threat that vessels pose to Rice's whales. Closely related Bryde's whales are the third most commonly reported whale species to be struck by vessels in the southern hemisphere (Van Waerebeek and Leaper 2008).

Rice's whales were one of the most impacted marine mammal species affected by the 2010 Deepwater Horizon (DWH) oil spill (DWHTrustees 2016). Following the DWH event, Rice's whales were estimated to have experienced 17% increase in mortality (confidence interval of 7 to 24%), 22% increase in failed pregnancies (confidence interval of 10 to 31%), and an 18% higher likelihood of having adverse health effects (confidence interval of 7 to 28%) (DWH-MMIQT 2015). An estimated 48% of the Rice's whale population was exposed to DWH oil, resulting in a 22% maximum decline in population size that will require an estimated 69 years until recovery, meaning the time it would take for the population to return to 95% of the baseline trajectory (DWH-MMIQT 2015). Based on a population model developed to estimate DWH oil spill impacts, it was projected that 1.4 Rice's whales died during 2016 to 2020 due to elevated mortality associated with oil exposure (DWH-MMIQT 2015).

Other threats include entanglement in fishing gear as several fisheries operate within the range of this species, and aquaculture, which represents a potential growing threat to Rice's whales with the continued development of this industry in the Gulf of America (Farmer et al. 2022b). In 2019, a Rice's whale stranded in the Everglades National Park. The necropsy found that a small piece of ingested hard plastic and accompanying stomach ulcerations to be the likely the cause of death, which indicates ingestion of plastic and marine debris is also a threat to this species (NMFS 2021d).

The Rice's whale has low productivity, including a slow growth rate, a relatively late age of maturity, long gestation periods, single offspring, and potentially biennial or longer reproductive periodicity. All of these characteristics limit the species' ability to recover from threats that impact its abundance and productivity (NMFS 2021d). As a long-lived marine mammal with low reproduction rates and a very small population size, the loss of one or more individuals could potentially drive the species towards extinction (Franklin 1980; Rosenfeld 2014). Few calves have been sighted during surveys since the DWH oil spill in 2010, and there have been frequent observations of individual whales in poor body condition. These data and observations, the small population size, their restricted range, and comparisons with other large whale species with similar demography, all suggest the species has likely been declining since at least that time (NMFS 2023i). Because the Rice's whale population is so small in size and has low genetic diversity, it is highly susceptible to further perturbations.

Critical Habitat

See Section 4.1.3 Rice's Whale Proposed Critical Habitat above.

Recovery Plan

NMFS is developing a recovery plan for this species. In the interim, NMFS has developed a recovery outline (NMFS 2021d) to provide a preliminary strategy for conservation of the Rice's whale (posted September 2020, updated August 27, 2021). The initial focus of the interim recovery program is to control threats to the species in its known range and gather additional information about the species (e.g., distribution and abundance, life history, and prey) through research and monitoring (NMFS 2021d).

4.2.4 North Atlantic Right Whale

In June 1970, all right whales were listed as endangered under the Endangered Species Conservation Act, the precursor to the ESA (35 FR 8495; codified at 50 CFR 17.11). Subsequently, when the ESA became law in 1973, right whales were included on the list of endangered species under that statute. In 2008, NMFS published a final rule listing right whales in the North Atlantic and North Pacific as separate endangered species under the ESA (73 FR 12024, March 6, 2008).

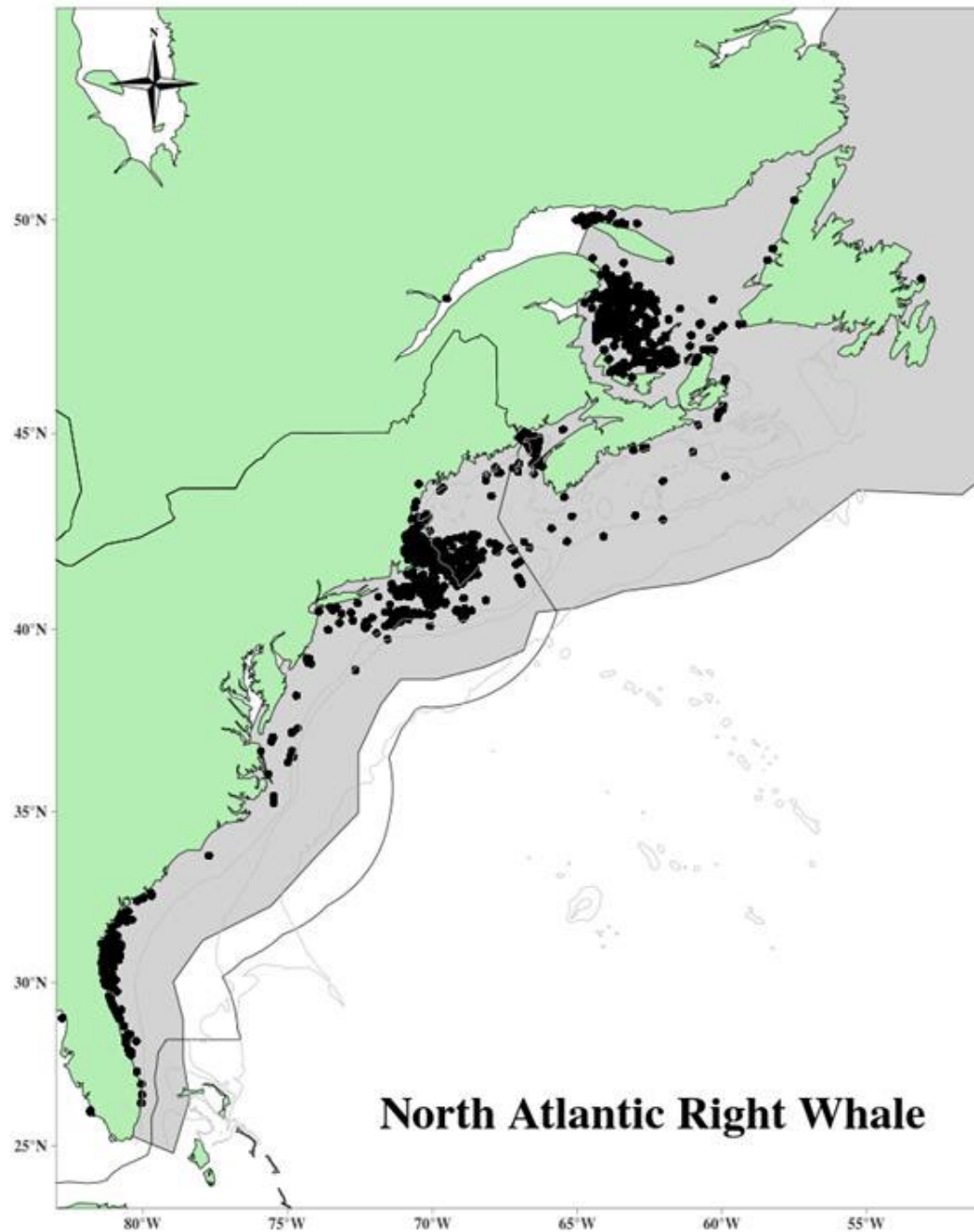


Figure 25. Approximate Range (shaded area) and Distribution of Sightings (dots) of Known North Atlantic Right Whales (Hayes et al. 2023)

Life History

The maximum lifespan of North Atlantic right whales is unknown, but one individual is thought to have reached around 70 years of age (Hamilton et al. 1998; Kenney 2009). Previous modelling efforts suggest that in 1980, females had a life expectancy of approximately 52 years of age, which was twice that of males at the time (Fujiwara and Caswell 2001). However, due to reduced

survival probability (Caswell et al. 1999), in 1995 female life expectancy was estimated to have declined to approximately 15 years, with males having a slightly higher life expectancy into their 20s (Fujiwara and Caswell 2001). A recent study demonstrated that females have substantially higher mortality rates than males (Pace et al. 2017), and as a result, also have substantially shorter life expectancies.

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

Pregnant North Atlantic right whales migrate south, through the Mid-Atlantic, to lower latitudes during late fall where they overwinter and give birth in shallow, coastal waters (Kenney 2009). Lactating females on the calving grounds spend up to 80% of their time within 3.5 m of the surface, mostly at rest, whereas non-lactating females who continue to migrate to the calving ground spend more time at depth, continuing to forage (Cusano et al. 2019; Dombroski et al. 2021). During spring, these females migrate back north with their new calves to higher latitude foraging grounds (NMFS 2017c). New England and Canadian waters are important feeding habitats for right whales, where they feed primarily on copepods (largely of the genera *Calanus* and *Pseudocalanus*). North Atlantic right whales must target high density prey patches to justify the energy expenditure of foraging. Van der Hoop et al. (2019) examined the foraging rates of North Atlantic right whales during ram filtration and found that they filter large rates of water (1.4 m²/s, on average) at slow speed to reduce drag, resulting in the consumption of greater than >60,000 copepods per minute based on previously determined density thresholds.

Some non-reproductive North Atlantic right whales (males, juveniles, non-reproducing females) also migrate south along the Mid-Atlantic region, although at more variable times throughout the winter, while others appear to not migrate south, and instead remain in the northern feeding grounds year-round or go elsewhere (Morano et al. 2012; Bort et al. 2015; NMFS 2017c). Little is known about North Atlantic right whale habitat use in the Mid-Atlantic, but recent acoustic data indicate near year-round presence of at least some whales off the coasts of New Jersey, Virginia, and North Carolina (Whitt et al. 2013; Hodge et al. 2015; Salisbury et al. 2016; Davis et al. 2017). While it is generally not known where North Atlantic right whales mate, some evidence suggests that mating may occur in the northern feeding grounds (Cole et al. 2013; Matthews et al. 2014).

Population Dynamics

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

Estimation of the current western North Atlantic right whale stock size is based on a state-space model of the sighting histories of individual whales identified using photo-identification techniques (Pace et al. 2017). This method does not account for recent calves since the model relies on individual animals being photographically identifiable from their callosity patterns, which are typically not stable until animals are greater than one year old. Using this method with data as of November 2020, Hayes et al. (2023) reported an abundance estimate of 338 individuals (95% CI: 325 to 350), with a minimum estimate of 332. Linden (2024a) combined the established capture-recapture framework (Pace et al. 2017) with a new birth-integration approach (Linden 2024b) to estimate a median population size at the start of 2023 of 372 whales (95% CI: 360 to 383).

The western North Atlantic population demonstrated overall growth of 2.8% per year between 1990 to 2010 from an estimated 270 individuals to 481 individuals (Pace et al. 2017; Hayes et al. 2023). However, this period of growth was followed by a period of decline from 2010 to 2020 when overall abundance declined 23.5%, from an estimated 481 to 338 individuals (Hayes et al. 2023). While the population continues to be in decline since 2011, the sharp decrease observed from 2015 to 2020 appears to have slowed, and the short-term trend (2021 to 2023) is positive (Linden 2024a).

Despite some recent improvements, the North Atlantic right whale population continues to experience annual mortalities above recovery thresholds (Linden 2024a). Between 1990 and 2015, survival rates appeared to be relatively stable, but differed between the sexes, with males having higher survivorship than females (males: 0.985 ± 0.0038 ; females: 0.968 ± 0.0073) leading to a male-biased sex ratio (approximately 1.46 males per female, Pace et al. 2017). The 2023 population estimate of 372 includes 215 males and 157 females, of which 70 are known reproductive females with previous evidence of calving (Linden 2024a). Reed et al. (2022) reported a steady decline in female North Atlantic right whale abundance from 2014 (185) to 2018 (142), with the largest decline seen in breeding females. Females born from 2000 onwards had an average 4% chance of transitioning from pre-breeder to breeder, compared to 8% for females born prior. These results demonstrate that the collapse in fecundity of breeding females and the failure of pre-breeders to start breeding are important factors in the current North Atlantic right whale decline in abundance (Reed et al. 2022).

There has been a considerable change in right whale habitat-use patterns in areas where most of the population had been observed in previous years, exposing the population to new anthropogenic threats (Hayes et al. 2023). The observed change in area-use patterns is correlated with a significant decrease in mean survival rates since 2010 (Pace 2021). There is strong evidence of reduced survival for adult females and younger whales, and for all individuals after 2010 (Linden 2024a). While post-2010 survival probability was lower on average, annual

fluctuations suggest there were recent increases in survival between 2020 and 2022 from the lower rates of survival in 2017 and 2019.

The large number of dead, seriously injured, or sublethally injured or ill North Atlantic right whales documented since 2017 has resulted in a NMFS declaration of an Unusual Mortality Event (UME). A UME, as defined under the MMPA, is a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response. As shown in Figure 26, the leading cause of this ongoing UME is human interaction, specifically from entanglements and vessel strike. The estimated total number of adult and juvenile right whale mortalities from 2018 to 2022 is 74 (54 incidental fishery-related; 20 vessel strike)(Hayes et al. 2024).

Pace III et al. (2021) used an abundance estimation model to derive estimates of cryptic mortality for North Atlantic right whales and found that observed carcasses accounted for only 36% of all estimated deaths during 1990 to 2017. They also note that cause of death determinations from detected carcasses may not be representative of cause-specific mortality rates in right whales given the large number of seriously injured whales from entanglement (i.e., 35 out of 157 in the UME; Figure 26) that are likely part of the unseen mortality.

Reed et al. (2024) investigated the influence of entanglement severity on survival and recruitment based on information from 199 known-aged females sighted between 1977 and 2018, combined with known entanglements of varying severity that were classified as minor, moderate or severe. Severe entanglements resulted in an average decline in survival of 27% for experienced non-breeders, 9% for breeders and 26% for pre-breeding females compared with minor/moderate entanglements and unentangled individuals. Surviving individuals with severe entanglements had low transitional probabilities to breeders, but individuals with minor entanglements had the lowest transitional probabilities (Reed et al. 2024).

While the impacts of entanglement on fitness and survival will vary greatly depending on entanglement severity, it is likely that most North Atlantic right whales either have been or will be adversely affected by this stressor at some point in their lifetime. From 1980 to 2017, 1,538 North Atlantic right whales entanglement interactions were documented involving 86% of the species, with some whales displaying evidence of as many as eight entanglement interactions over the course of a lifetime. (Moore et al. 2021).

North Atlantic right whales had one-third the calving success of closely related Southern Right whales between 1992 and 2016 (Corkeron et al. 2018). Birth rates remain significantly below what is expected, and the average inter-birth interval remains high. During 1990 to 2023, at least 518 calves (including neonate mortalities) were born into the population (Hayes et al. 2023). The number of calves born annually ranged from 0 to 39, and averaged 15 but was highly variable ($SD=9.1$). No calves were born in the winter of 2017 or 2018. Eleven mother/calf pairs were sighted in the 2023 calving season, down from 15 mother/calf pairs in 2022 and 18 in 2021 (Pettis and Hamilton 2024). The most recent calf mortality probability was estimated at 0.031 (Linden 2024).

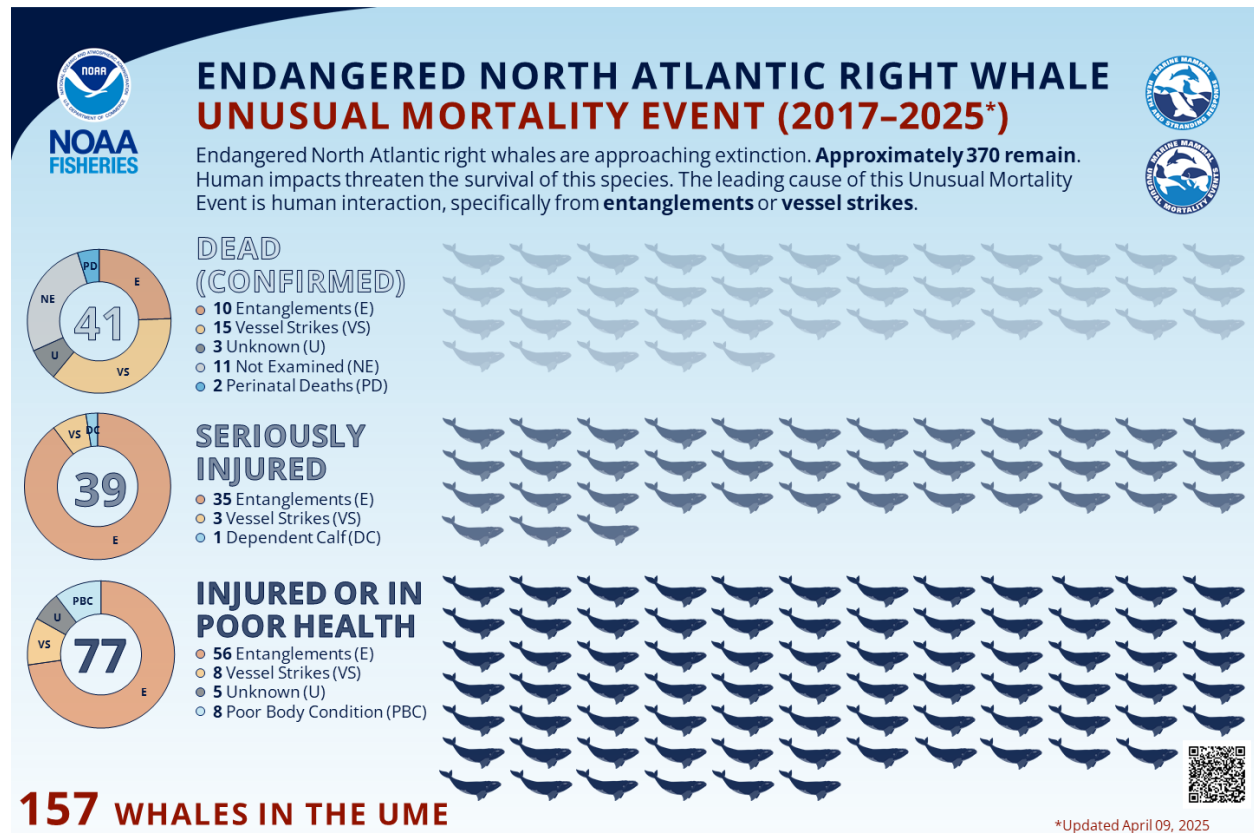


Figure 26. Schematic of the 2017-2025 North Atlantic Right Whale UME Showing the Number of Whales Killed, Seriously Injured, and Injured/Poor Health (through April 9, 2025), and the Likely Cause of Injury or Death (NMFS 2025b)

Nutrition is a major determinant of reproductive success in many marine mammals, and the available evidence suggests that at least some of the observed variability in the calving rates is related to variability in nutrition (Fortune et al. 2013). North Atlantic right whales are growing to shorter adult lengths than in earlier decades (Stewart et al. 2021) and are in poor body condition compared to Southern right whales (Miller et al. 2011; Christiansen et al. 2020). Pirotta et al. (2024) found that body size was strongly associated with a female's calving probability at each reproductive opportunity. This relationship explained 62% of the variation in calving among reproductive females, along with their decreasing health (20%). Slow growth and poor body condition have been linked to a combination of documented regime shifts in primary feeding habitats (Record et al. 2019; Meyer-Gutbrod et al. 2023), and increased energy expenditures related to non-lethal entanglements (Rolland et al. 2016; van der Hoop et al. 2017b), which will likely continue to negatively impact calving rates. Chronically entangled North Atlantic right whales may carry fishing gear for months to years, and often show signs of considerable loss in energy reserves over that time period, as evidenced by emaciation (Moore et al. 2021). Impacts of entanglements persist even after disentanglement due to time needed for recovery, which may

take several months to over a year (van der Hoop et al. 2017a). Right whales are also exposed to a variety of biotoxins and parasites, but their role in health determination remain unclear (Moore et al. 2021).

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

With extremely low levels of genetic diversity, limited options for mates, and variation in reproductive success across females, there is concern regarding the potential for genetic limitations of population growth from inbreeding depression. Crossman et al. (2024) sequenced approximately 2% of the genome of 105 female North Atlantic right whales and combined genomic inbreeding estimates with individual fecundity values to assess evidence of inbreeding depression. They found that while inbreeding depression could not explain the variance in reproductive success of females, inbreeding depression may be affecting the viability of inbred fetuses—potentially lowering the reproductive success of the species as a whole. While still far fewer calves are being born each year than expected, the small role of genetics underlying variance in female fecundity suggests that variance may be explained by external factors that can potentially be mitigated through protective mitigation measures designed to reduce serious injury and mortality from human activities (Crossman et al. 2024).

The North Atlantic right whale population is narrowly distributed in temperate and sub-polar latitudes in the North Atlantic Ocean. Currently they are almost exclusively found in the Western North Atlantic, although individuals have been historically recorded elsewhere including Newfoundland, southeast of Greenland, Norway, the Azores, off Brittany in northwestern France (Kraus and Rolland 2007), as well in the Gulf of America. More recently, in February of 2025 two North Atlantic right whales were sighted in the Gulf of America off of Panama City Beach, Florida¹². In the eastern North Atlantic, sightings of right whales are so rare that the population may be functionally extinct (Best et al. 2001).

In the western North Atlantic, North Atlantic right whales are primarily found from their calving grounds in lower latitudes off the coast of the southeastern United States to their feeding grounds in higher latitudes off the coast of New England and Nova Scotia (Hayes et al. 2017). Individuals' movements within and between habitats across the range are extensive (Hayes et al. 2023). Passive acoustic studies of right whales have demonstrated their year-round presence in

¹² <https://www.wjhg.com/2025/02/13/critically-endangered-right-whales-spotted-gulf/>

the Gulf of Maine (Morano et al. 2012; Bort et al. 2015), New Jersey (Whitt et al. 2013), and Virginia (Salisbury et al. 2016).

Changes in the physical oceanography of the Northwest Atlantic stemming from changing environmental conditions impact the foraging ecology and distribution of North Atlantic right whales (Meyer-Gutbrod et al. 2023). Meyer-Gutbrod et al. (2023) analyzed right whale sightings and *Calanus sp.* abundances over three decades (1990 to 2018) to examine decadal patterns in monthly habitat use and prey availability. In the decades of the 1990s and the 2010s, prey was less abundant than in the 2000s, corresponding to reduced use of the Southeast U.S. calving grounds in the winter, increased use of Cape Cod Bay in winter and spring, and reduced use of Roseway Basin (off Nova Scotia) in the fall. In the 2010s, right whale sightings increased in Southern New England and the Gulf of St. Lawrence in the spring and summer, respectively (Meyer-Gutbrod et al. 2023). Between 2012 and 2016, visual surveys detected fewer individuals in the Great South Channel and the Bay of Fundy (Davies et al. 2019), while the number of individuals using Cape Cod Bay in spring increased (Mayo et al. 2018; Ganley et al. 2019). Right whales abandoned the central Gulf of Maine in winter, but have since been seen in large numbers in a region south of Martha's Vineyard and Nantucket Islands (Leiter et al. 2017; Quintana-Rizzo et al. 2021). Right whale presence in this area, which lies outside of the Northeastern Foraging Critical Habitat area, is nearly year round with the highest sighting rates from winter through early spring (Hayes et al. 2023). Close to a quarter of the population may be present in this area at any given time between December and May (Hayes et al. 2023).

Vocalization and Hearing

North Atlantic right whales vocalize during social interactions and are likely to communicate over long distances (Parks and Clark 2007; Tyson et al. 2007; Parks et al. 2011b; McCordic et al. 2016). Calls among North Atlantic right whales are similar to those of other right whale species, and can be classified into six major call types: screams, gunshots, blows, upcalls, warbles, and downcalls (McDonald and Moore 2002; Parks and Tyack 2005; Parks et al. 2011b; Soldevilla et al. 2014). North Atlantic right whales produce the majority of their calls within the 50-600 Hz range, and they are short in duration; however, there is variation in their acoustic behavior between social contexts and among behaviors (Matthews and Parks 2021). Source levels range from 137 to 192 dB re: 1 μ Pa at 1 m (rms), with gunshot calls having higher source levels as compared to other call types (Parks and Tyack 2005; Hatch et al. 2012; Trygonis et al. 2013). These levels are low compared to some other baleen whales, which may put North Atlantic right whales at greater risk of communication masking compared to other species (Clark et al. 2009b; Hatch et al. 2012). Individual calls typically have a duration of 0.04 to 1.5 seconds depending on the call type, and bouts of calls can last for several hours (Vanderlaan et al. 2003; Parks and Tyack 2005; Parks et al. 2012a; Trygonis et al. 2013).

Vocalizations vary by demographic and context. Upcalls are perhaps the most ubiquitous call type, being commonly produced by all age and sex classes (Parks et al. 2011b). Other non-stereotyped tonal calls (e.g., screams) are also produced by all age-sex classes (Parks et al. 2011b) but have been primarily attributed to adult females (Parks and Tyack 2005). Warbles are thought to be produced by calves and may represent 'practice' screams (Parks and Tyack 2005;

Parks and Clark 2007). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Gunshots appear to be largely or exclusively male vocalizations and may be a form of vocal display (Parks et al. 2005; Parks and Clark 2007; Parks et al. 2011b). Downcalls have been less frequently recorded, and while it is not known if they are produced by specific age-sex classes, they have been recorded in various demographic make ups of surface-active groups (Parks and Tyack 2005).

All types of right whale calls have been recorded in surface-active groups, with smaller groups vocalizing more than larger groups and vocalization being more frequent in the evening, at night, and perhaps on the calving grounds (Matthews et al. 2001; Parks and Clark 2007; Morano et al. 2012; Parks et al. 2012a; Trygonis et al. 2013; Matthews et al. 2014; Soldevilla et al. 2014; Salisbury et al. 2016). Screams are usually produced within 10 m of the surface (Matthews et al. 2001). Upcalls have been detected nearly year-round in Massachusetts Bay, peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of upcall and gunshot vocalizations from November through January, possibly associated with mating (Morano et al. 2012; Mussoline et al. 2012; Matthews et al. 2014; Bort et al. 2015). Upcalls may be used for long distance communication (McCordic et al. 2016), including to reunite calves with mothers (Parks and Clark 2007; Tennessen and Parks 2016). In fact, a recent study indicates they contain information on individual identity and age (McCordic et al. 2016). However, while upcalls are frequently heard on the calving grounds (Soldevilla et al. 2014), they are infrequently produced by mothers and calves here perhaps because the two maintain visual contact until calves are approximately three to four months of age (Parks and Clark 2007; Trygonis et al. 2013; Parks and Van Parijs 2015; Tennessen and Parks 2016).

Parks et al. (2019) found that right whale mother–calf pairs have a strong shift in repertoire usage, significantly reducing the number of higher amplitude, long-distance communication signals they produced when compared with juvenile and pregnant whales in the same habitat. These observations show that right whale mother–calf pairs rely upon acoustic crypsis, potentially to minimize the risk of acoustic eavesdropping by predators.

North Atlantic right whales shift calling frequencies, particularly those of upcalls, and increase call amplitude over both long and short term periods due to exposure to vessel sound, which may limit their communication space by as much as 67% compared to historically lower sound conditions (Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2009; Parks et al. 2011a; Hatch et al. 2012; Parks et al. 2012b).

There are no direct data on the hearing range of North Atlantic right whales, although they are considered to be part of the low frequency¹³ cetacean hearing group with a hearing range between 7 Hz and 36 kHz (NMFS 2024g). However, based on anatomical modeling, their

¹³ As discussed in Section 6.1.1, for the Phase IV NAEMO auditory impacts analysis North Atlantic right whales are included in the very-low frequency cetacean hearing group.

hearing range is predicted to be from 10 Hz to 22 kHz with a functional range probably between 15 Hz to 18 kHz (Parks et al. 2007b).

Status

While historical North Atlantic right whale abundance remains difficult to estimate, synthesis of genomic research, catch records, whaling effort, and availability of foraging habitat over time suggests a pre-exploitation population size of between 9,000 and 22,000 individuals (Monsarrat et al. 2016; Laist 2017). With whaling now prohibited, the two major known human causes of mortality are vessel strikes and entanglement in fishing gear. There is also uncertainty regarding the effect of long-term sublethal entanglements, emerging stressors including changes in environmental conditions, and the compounding effects of multiple continuous stressors that may be limiting North Atlantic right whale calving and recovery (NMFS 2022b). Habitat important to North Atlantic right whales has changed in response to an oceanographic regime shift that has altered prey availability, which will likely continue to fluctuate as a result of changing environmental conditions (NMFS 2022b; Meyer-Gutbrod et al. 2023).

From 1990 to 2010, the population experienced overall growth consistent with one of its recovery goals. However, the population has been declining since 2010, and a UME has been in effect for this population since 2017. While the sharp population decline observed from 2015-2020 appears to have slowed in the past few years, annual mortalities continue to be above population recovery thresholds. Since 2017, right whale calving rates have remained below average and overall body condition of the population has worsened (Corkeron et al. 2018; Christiansen et al. 2020). Currently, none of its recovery goals have been met (NMFS 2017c). Given the current status and low population size, the species' resilience to future perturbations is considered very low.

Critical Habitat

See Section 4.1.3 North Atlantic Right Whale Designated Critical Habitat above.

Recovery Goals

The objectives of the 2005 North Atlantic Right Whale Recovery Plan (NMFS 2005d) are as follows:

- Significantly reduce sources of human-caused death, injury and disturbance;
- Develop demographically-based recovery criteria;
- Identify, characterize, protect and monitor important habitats;
- Monitor the status and trends of abundance and distribution of the western North Atlantic right whale population; and
- Coordinate Federal, State, local, international and private efforts to implement the recovery plan.

The 2005 recovery plan included the following criteria for down-listing the species from endangered to threatened status:

- The population ecology (range, distribution, age structure, and gender ratios, etc.) and vital rates (age-specific survival, age-specific reproduction, and lifetime reproductive success) of right whales are indicative of an increasing population;
- The population has increased for a period of 35 years at an average rate of increase equal to or greater than 2% per year;
- None of the known threats are known to limit the population's growth rate; and
- Given current and projected threats and environmental conditions, the population has no more than a 1% chance of quasi-extinction in 100 years (NMFS 2005d).

Specific criteria for delisting North Atlantic right whales were not included the 2005 recovery plan.

4.2.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans. The sei whale was originally listed as endangered throughout its range under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained listed after the passage of the ESA in 1973.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of 10 to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between 6 and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill), small schooling fishes, and cephalopods (Wiles 2017). Sei whales filter prey through their baleen, and have the unique ability to capture prey via engulfment (like other rorquals), or via skimming on lower prey concentrations (Prieto et al. 2012). Although known to eat fish in other oceans, North Atlantic sei whales are largely planktivorous, feeding primarily on euphausiids and copepods (Flinn et al. 2002).

Population Dynamics

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

Scientifically reliable abundance estimates are not available for the North Atlantic and Southern Hemisphere populations, due to inherent uncertainties in sampling design, data collection methodologies, and use of outdated abundance estimates (NMFS 2021e). Sei whale that may be affected by the proposed action would be from the Nova Scotia stock which includes the U.S. Atlantic coast through Cape Breton, Nova Scotia (Hayes et al. 2023). The best estimate of abundance for the Nova Scotia stock sei whales is 6,292 (Hayes et al. 2023). A trend analysis has not been conducted for this sei whale stock due to the relatively imprecise abundance estimates and long survey interval (Hayes et al. 2023).

The southern portion of the Nova Scotia stock's range during spring and summer includes the northern portions of the U.S. Atlantic EEZ (i.e., Gulf of Maine and Georges Bank). Spring is the period of greatest abundance in U.S. Atlantic waters, with sightings concentrated along the eastern margin of Georges Bank, into the Northeast Channel area, south of Nantucket, and along the southwestern edge of Georges Bank (Hayes et al. 2023). Persistent year-round detections in Southern New England and the New York Bight highlight this as an important region for the species (Hayes et al. 2023).

There are an estimated 35,000 sei whales in the North Pacific Ocean (NMFS 2021e). There are no estimates of the growth rate of sei whale populations in the North Pacific. Besides the Nova Scotia stock, there are two other small stocks within U.S. waters: West Coast and Hawaii. The best abundance estimate for sei whales in the waters of the U.S. West Coast is 519 (Barlow 2016), and for Hawaii is 391 whales (Bradford et al. 2017).

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Genetic studies indicate that the sei whale has moderate to high genetic diversity, providing the raw genetic material required to adapt to changes in its environment, and thus some resilience to such perturbations (NMFS 2021e). Taguchi et al. (2021) conducted the first population genetic study of sei whales worldwide using microsatellite DNA. They reported high genetic diversity in the Southern Hemisphere and North Pacific. Sei whales appear to be significantly differentiated among oceanic regions hierarchically, and sei whales in the Southern Hemisphere are more closely related to sei whales in the North Pacific than sei whales in the North Atlantic (NMFS 2021e; Taguchi et al. 2021).

Vocalizations and Hearing

Data on sei whale acoustic behavior and characteristics is limited. Calls attributed to sei whales are low frequency, generally between 38 and 100 Hz, but there are some reports of higher frequency calls (3.5 kHz) (McDonald et al. 2005; Baumgartner and Fratantoni 2008).

Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson and Richardson 1995). Source levels of 189 ± 5.8 dB re: 1 μ Pa at 1 m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al. 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same low frequencies that they produce and are likely most sensitive to this frequency range (Richardson et al. 1995a; Ketten 1997). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hz to 36 kHz (NMFS 2024g).

Status

The sei whale is endangered as a result of past commercial whaling. Due to a lack of comprehensive abundance and distribution data for all three ocean basins, and absence of dedicated systematic surveys, there is no scientifically rigorous estimate of global abundance. As such, there are insufficient data to determine population trends for sei whales. A crude estimate of global decline from approximately 250,000 whales before whaling to perhaps 32,000 whales by the 1970s to 1980s is reported (Wiles 2017). Sei whales were estimated to have been reduced to 20% (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). Currently, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales.

The status of the Nova Scotia stock in the U.S. Atlantic is unknown (Hayes et al. 2023). Although the population in the North Pacific is expected to have grown since being given protected status in 1976, the possible effects of continued unauthorized takes and ongoing threats make this uncertain (Carretta 2021). Ongoing threats include vessel strikes, fisheries interactions (including entanglement), changing environmental conditions (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed the following goals to recover sei whale populations:

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

Threats to sei whales are discussed in further detail in the environmental baseline section of this opinion (Section 5). Downlisting criteria for sei whales include:

- Factors that may limit population growth (i.e., those that are identified as either high, medium, or unknown impact to recovery) have been identified and are being or have been addressed to the extent that they allow for continued growth of populations in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere).
- The population in each ocean basin satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) and has at least 1,500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males) (National Marine Fisheries Service 2011).

4.2.6 Sperm Whale

The sperm whale is widely distributed and found in all major oceans. The sperm whale was originally listed as endangered throughout its range under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained listed after the passage of the ESA in 1973.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity is reached between 7 and 13 years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their late teens and early twenties. Sperm whales mostly inhabit areas with a water depth of 600 m or more, and are uncommon in waters less than 300 m deep. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs). Sperm whales are one of the deepest and longest diving mammalian species, with recorded dives up to 3 km down and durations in excess of two hours (Clarke 1976; Watkins 1985; Watkins et al. 1993). However, typical dives are generally shorter (25 to 45 minutes) and shallower (400 to 1,000 m). Dives are separated by 8 to 11 minutes rests at the surface (Gordon 1987; Papastavrou et al. 1989; Jochens et al. 2006; Watwood et al. 2006). Sperm whales typically travel about 3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Population Dynamics

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

The sperm whale is the most abundant of the large whale species. Using a habitat suitability model, Whitehead and Shin (2022) extrapolated estimates of sperm whale abundance from visual and acoustic surveys. The current global estimate is about 850,000 sperm whales, down from about two million before the start of whaling in the 1700's, which represents a decline of approximately 57% (Whitehead and Shin 2022).

There are no reliable estimates for sperm whale abundance across the entire North Atlantic Ocean. The best abundance estimate for this stock, based on 2021 survey data from Central Florida to the lower Bay of Fundy, is 5,895 (CV=0.29) (Hayes et al. 2023). A population trend is not available for the North Atlantic sperm whale stock. The best abundance estimate for the northern Gulf of Mexico stock is 1,180 (CV=0.22) (Garrison et al. 2020; Hayes et al. 2021). Garrison et al. (2020) found no significant differences in abundance estimates across multiple survey years (i.e., 2003-2004, 2009, and 2017-2018), suggesting a stable sperm whale population

trend in U.S. Gulf of America waters over this time period. However, the statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long intervals between surveys (Hayes et al. 2021). Frasier et al. (2024a) documented density declines for seven (out of eight monitored) odontocete species in the northeastern Gulf of America in the decade after the Deepwater Horizon oil spill, including a 31% decline in sperm whales. There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands sperm whale stock.

In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 in 1993 (Carretta 2022). Population estimates are also available for two of three U.S. stocks that occur in the Pacific: the California/Oregon/Washington stock is estimated to consist of 2,106 individuals; the Hawaii stock is estimated to consist of 5,707 individuals (Carretta 2022). Moore and Barlow (2017) reported abundance of the California/Oregon/Washington stock appears stable from 1991 to 2008, and additional data from the 2014 survey did not change that conclusion.

The distribution of the North Atlantic stock of sperm whales in the U.S. EEZ occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions (Figure 27). In U.S. Atlantic EEZ waters, there appears to be a distinct seasonal cycle: sperm whales are concentrated east and northeast of Cape Hatteras in the winter; the distribution center shifts northward to east of Delaware and Virginia in the spring; expansion in areas east and north of Georges Bank and off New England in the summer; and higher level of occurrence south of New England on the continental shelf in the fall (Hayes et al. 2020). Boisseau et al. (2024) reported high densities of sperm whales in both winter and spring across the Outer Continental Shelf of the U.S. Mid-Atlantic, indicating this area provides an important foraging habitat for this species. The high densities documented in spring were related to interactions between bathymetry and dynamic oceanographic variables, with sperm whales being most prevalent in marginal regions of the Gulf Stream characterized by warm core rings, eddies and edges. In a study of sperm whale proximity to a Southern New England wind energy area, Westell et al. (2024) detected sperm whales year-round but the majority (78%) of days with acoustic occurrences were between May and August.

The Northern Gulf of Mexico stock of sperm whales is widely distributed on the continental slope and in oceanic waters of the Gulf of America year-round (Hayes et al. 2021). Morano et al. (2020) studied sperm whale occurrence in the northern Gulf of America in 2010 and 2011 following the Deepwater Horizon oil spill. They found that, in general, sperm whale occurrence cyclically decreased and increased by approximately 60% simultaneously across all study regions on a 6 to 11 month cycle. These results suggest that sperm whales were not leaving one region for another along the shelf edge; rather, that they were moving away from the shelf edge during the winter, most likely to areas farther off the continental shelf. Their data also show that sperm whales consistently occurred more often in the region surrounding the Mississippi Delta than in the regions to the west of the Mississippi Delta and to the south, near the Dry Tortugas (Morano et al. 2020).

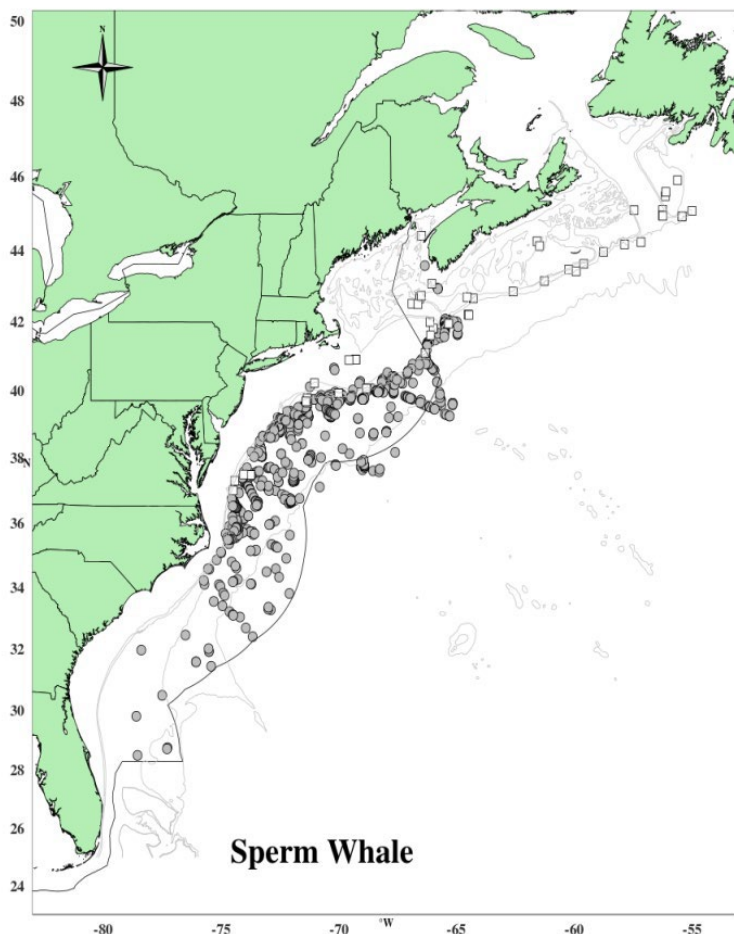


Figure 27. Distribution of Sperm Whale Sightings from Shipboard (circles) and Aerial (squares) Summer Surveys between 1998 and 2016 (Hayes et al. 2020) Lizewski et al. (2025) used genetic samples from 377 individual sperm whales collected from 2000 to 2017 to support previous findings of genetic isolation of the Gulf of America population from populations in the Western North Atlantic and Caribbean. This study also reported significant changes in population structure within the Gulf of America across both space and time. In particular, the Central subregion, where the 2010 Deepwater Horizon oil spill originated, underwent a significant change in haplotype frequencies across time, with implications for disruption of matrilineal population structure (Lizewski et al. 2025).

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineal related groups (Lyrholm and Gyllenstein 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). Furthermore, sperm whales from the Gulf of America, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and ‘Allee’ effects, although the extent to which is currently

unknown. Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles.

Vocalizations and Hearing

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

Long, repeated clicks are associated with feeding and echolocation (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997; Miller et al. 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997; Rendell and Whitehead 2004).

Sperm whales are considered to be part of the high frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA 2016). Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale’s inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm

whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins et al. 1985).

Status

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed; however, illegal hunting may occur. Current potential threats likely affecting sperm whale recovery include vessel strikes, entanglement in fishing gear, oil spills anthropogenic noise, exposure to contaminants, changing environmental conditions, and marine debris (NMFS 2015c). The species' large population size shows that it may be somewhat resilient to current threats. However, the magnitude of many of these threats is highly uncertain, and the impact of some threats (e.g., contaminant levels and changing environmental conditions) may be intensifying (NMFS 2015c).

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed the following goals to recover sperm whale populations:

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

The 2010 sperm whale recovery plan (NMFS 2010a) defines three recovery populations by ocean basin (the Atlantic Ocean/Mediterranean Sea, Pacific Ocean, and Indian Ocean) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, changing environmental conditions, direct harvest, oil spills, anthropogenic noise, and ship collision. Downlisting criteria for sperm whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population. To qualify for downlisting, each recovery population must also have no more than a 1% chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10% chance of becoming endangered in 20 years.

4.2.7 Green Sea Turtle – North Atlantic DPS

The green turtle was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two ESA-listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green turtles as threatened or endangered under the ESA. The green turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, sub-tropical and, to a lesser extent, temperate waters. The North

Atlantic DPS of green turtle, which is ESA-listed as threatened, is found in the North Atlantic Ocean and Gulf of America (Figure 28).

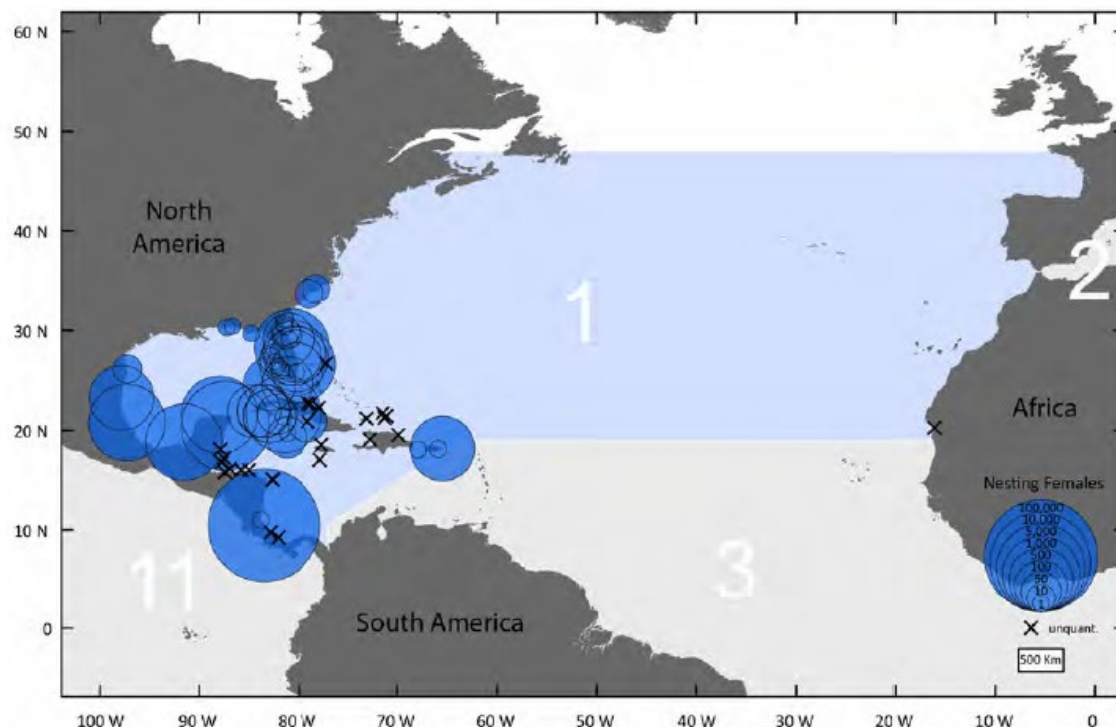


Figure 28. Geographic Range of the North Atlantic DPS of Green Turtles, with Location and Abundance of Nesting Females (Seminoff et al. 2015)

Life History

The green turtle is the largest of the hard-shell sea turtles, growing to a weight of 158.8 kilograms and a straight carapace length of greater than 1 m. Age at first reproduction for females is 20 to 40 years. Green turtles lay an average of three nests per season with an average of 100 eggs per nest (Seminoff et al. 2015). The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult sea turtles exhibit nesting site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Reproductive individuals use the waters adjacent to nesting beaches for courtship and copulation (i.e., mating); however, mating may also occur at foraging areas and along migratory corridors (Karl et al. 1992; Roberts et al. 2004). It is essential to the conservation of green turtle DPSs that such areas remain free from obstructions and disturbances that would harm or interrupt copulating turtles (NMFS 2023b). Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and

protected bays and lagoons. Green turtles are omnivores, foraging on seagrasses, algae, and invertebrates (Esteban et al. 2020).

Population Dynamics

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

The green turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than 80 countries. Worldwide, nesting data at 464 sites indicate that approximately 5643,000 females nest each year (Seminoff et al. 2015). Compared to other populations, the North Atlantic DPS exhibits the highest nester abundance, with approximately 167,424 females at 73 nesting sites (Figure 28). The largest nesting site in the North Atlantic DPS is in Tortuguero, Costa Rica, which hosts 79% of nesting females for the DPS (Seminoff et al. 2015).

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

DiMatteo et al. (2024) modeled survey data to estimate in-water abundance of juvenile and adult green sea turtles (> 40 cm) along the U.S. Atlantic Coast. Mean green sea turtle abundance was 63,674 (90% CI 23,381–117,610). Monthly predicted abundance ranged from a high of 96,935 in July to a low of 49,720 in January and was generally higher in warm months and lower in cool months. Predicted density was high off of Georgia and Florida coasts year-round, particularly the Florida Keys. The Florida Keys are a known hotspot for green turtles given the abundant seagrass beds, which are a preferred foraging habitat.

The North Atlantic DPS of green turtle has a globally unique haplotype, which was a factor in defining the discreteness of the population. A relatively low level of spatial structure is detected in this DPS due to shared common haplotypes (Seminoff et al. 2015). Evidence from mitochondrial DNA studies indicate that there are at least four independent nesting sub-populations in Florida, Cuba, Mexico, and Costa Rica (Seminoff et al. 2015). More recent genetic analysis indicates that designating a new western Gulf of America management unit might be appropriate (Shamblin et al. 2016).

Green turtles from the North Atlantic DPS range from the boundary of South and Central America (7.5° North, 77° West) in the south, throughout the Caribbean, the Gulf of America, and the U.S. Atlantic coast to New Brunswick, Canada (48° North, 77° West) in the north. The range of the North Atlantic DPS then extends due east along latitudes 48° North and 19° North to the western coasts of Europe and Africa (Figure 28). Nesting occurs primarily in Costa Rica, Mexico, Florida, and Cuba.

In U.S. Atlantic and Gulf of America waters, green turtles are found in inshore and nearshore waters from Texas to Maine. In the late spring and early summer, green turtles migrate to Mid-Atlantic foraging grounds (Barco et al. 2018). Juveniles use the estuarine and nearshore waters of the panhandle of Florida throughout the year (Seminoff et al. 2015). In the northern Gulf of America, green sea turtles prefer the coastal habitats (e.g., lagoons, channels, inlets, bays) of southern Texas (Wildermann et al. 2019).

Hearing

Sea turtles primarily detect low frequencies with typical hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Piniak et al. (2016) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 Hz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Other studies have similarly found greatest sensitivities between 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Ridgway et al. 1969; Bartol and Ketten 2006). More details can be found in the sea turtle acoustic and explosive effects analyses section below (Section 6.2.1).

Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance as a result of over-exploitation. Nesting beaches throughout some portions of the North Atlantic DPS are susceptible to coastal development and associated beachfront lighting, erosion, and sea level rise. Nests and hatchlings are susceptible to predation which is prevalent throughout the beaches of the North Atlantic DPS and can be an increasing threat without nest protection and predatory control programs in place (Seminoff et al. 2015). The extent of harmful fishing practices and marine pollution is broad with high levels occurring in waters where high numbers of green turtles are known to forage and migrate. Along with degraded foraging and migratory areas, green turtles are also susceptible to direct harvesting. Current legal and illegal harvest of green turtles and eggs for human consumption continues in the eastern Atlantic and the Caribbean (Seminoff et al. 2015). The prevalence of Fibropapillomatosis disease has reached epidemic proportions in some parts of the North Atlantic DPS, although the extent to which this will affect the long-term outlook for green turtles in the North Atlantic DPS is unknown (Seminoff et al. 2015).

The North Atlantic DPS is characterized by geographically widespread nesting with eight sites having high levels of abundance (i.e., > 1,000 nesters). The dispersed location of nesting sites provides a level of habitat use diversity and population resilience which reduces overall extinction risk (Seminoff et al. 2015). All major nesting populations in this DPS demonstrate long-term increases in abundance (Seminoff et al. 2015). While the ongoing threats of pollution, habitat loss through coastal development, beachfront lighting, fisheries bycatch, and changing environmental conditions continue, the North Atlantic DPS appears to be somewhat resilient to future perturbations.

Critical Habitat

NMFS designated critical habitat for the green sea turtle North Atlantic DPS in 1998, which includes coastal waters surrounding Culebra Island, Puerto Rico. However, this critical habitat does not overlap with the action area or any stressors resulting from the proposed action.

See Section 4.1.3 Green Sea Turtle – North Atlantic DPS Designated Critical Habitat for details regarding new critical habitat proposed for this DPS in 2024.

Recovery Goals

In response to the current threats facing the species, NMFS and USFWS (1991) identified the following major actions needed to recover the U.S. Atlantic population of green sea turtles:

- Provide long-term protection to important nesting beaches;
- Ensure at least 60% hatch success on major nesting beaches;
- Implement effective lighting ordinances or lighting plans on nesting beaches;
- Determine distribution and seasonal movements for all life stages in marine environment;
- Minimize mortality from commercial fisheries; and
- Reduce threat to population and foraging habitat from marine pollution.

See the NMFS and USFWS 1991 recovery plan (NMFS and USFWS 1991) for the Atlantic population of green turtles for complete downlisting/delisting criteria for recovery goals for the species.

4.2.8 Hawksbill Turtle

The hawksbill turtle was first listed under the Endangered Species Conservation Act and has been listed as endangered under the ESA since 1973. The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, sub-tropical oceans (Figure 29).

Life History

Hawksbill turtles reach sexual maturity at 20 to 40 years of age. Based on skeletochronological analysis for hawksbills stranded along U.S. coastlines, Avens et al. (2021) predicted an adult sexual maturity age ranging from 15 to 25 years old, suggesting a younger average age at maturity for hawksbills in U.S. waters. Females return to their natal beaches every two to five years to nest, and nest an average of three to five times per season. Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately 22 to 25 cm in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbill turtles use their sharp beak-like mouths to feed on sponges and corals. Hawksbill turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged hawksbills have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging ranges from a few hundred to a few thousand kilometers (Miller et al. 1998; Horrocks et al. 2001).

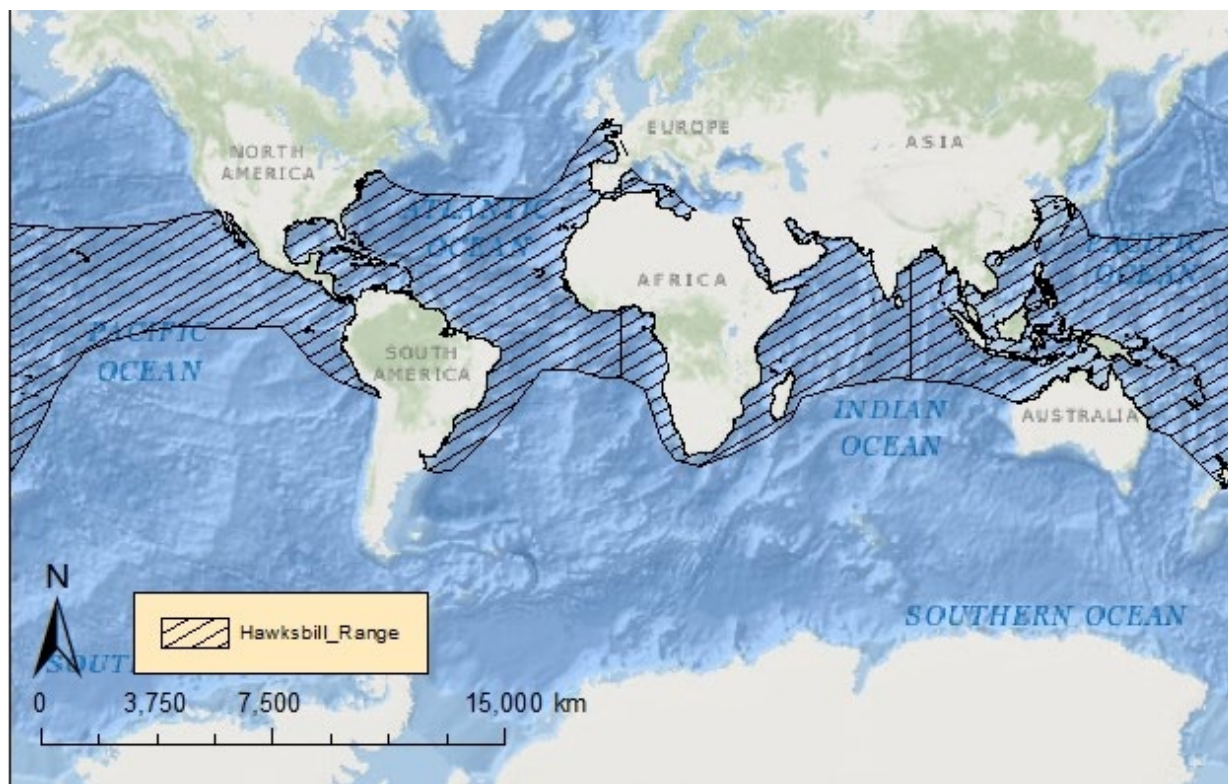


Figure 29. Map Identifying the Range of the Endangered Hawksbill Sea Turtle

Population Dynamics

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

Long-term data on hawksbill turtle nesting indicate that among the sites for which historic trends could be assessed (n=63), all (100%) showed a decline during the long-term period from greater than 20 to 100 years ago. Among the 41 sites for which recent trend data are available, 10 (24%) were increasing, 3 (7%) were stable, and 28 (68%) were decreasing at the time of the last hawksbill 5-year review (NMFS 2013c).

Surveys at 88 nesting sites worldwide indicate that 22,004 to 29,035 females nest annually (NMFS 2013c). In general, hawksbill turtles are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining. For the Atlantic Ocean population, the greatest number of hawksbill nests are laid in Mexico, Cuba, and Barbados, but nesting occurs throughout the Insular Caribbean. The most significant nesting within the United States occurs in Puerto Rico and the U.S. Virgin Islands. Each year, about 500 to 1,000 hawksbill nests are laid on Mona Island, Puerto Rico and another 100 to 150 nests on Buck Island Reef National Monument off St. Croix.

In the continental United States, nesting is rare and is restricted primarily to the southeast coast of Florida and the Florida Keys.

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (McClellan et al. 2010; Monzon-Arguello et al. 2010). Hawksbill turtles in the Caribbean Sea seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000 to 300,000 years ago (Leroux et al. 2012).

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, sub-tropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbill turtles can be found in *Sargassum* mats; post-oceanic hawksbill turtles may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Musick and Limpus 1997; Bjørndal and Bolten 2010).

Hawksbills are in general considered extralimital north of Florida, and have regularly been observed along the coasts of Texas and Florida, and to a lesser extent along other Gulf of America and Atlantic states (Gorham et al. 2014; Avens et al. 2021). In Florida, hawksbills regularly occur in the nearshore waters off the southeastern coast, and throughout the Florida Keys. Juvenile hawksbills have been observed along the jetties near Port Aransas, Texas and within the coral reefs at the Flower Garden Banks National Marine Sanctuary in the western Gulf of America (Avens et al. 2021).

Hearing

Sea turtles primarily detect low frequencies with typical hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Piniak et al. (2012) found hawksbill turtle hatchlings capable of hearing underwater sounds at frequencies of between 50 Hz to 1.6 kHz (maximum sensitivity at 200 to 400 Hz). More details can be found in the sea turtle acoustic and explosive effects analyses section below (Section 6.2.1).

Status

The greatest threats to hawksbill turtles are overharvesting of sea turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbill turtles are harvested for their meat and carapace, which is sold as tortoiseshell. Eggs are taken at high levels, especially in Southeast Asia where collection approaches 100% in some areas. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alter the behavior of nesting adults. The species' resilience to additional perturbation is low.

Critical Habitat

Hawksbill sea turtle designated critical habitat does not overlap with the action area or any stressors resulting from the proposed action.

Recovery Goals

See the 1992 Recovery Plan for the U.S. Caribbean, Atlantic and Gulf of Mexico (NMFS and USFWS 1993) and the 1998 Recovery Plan for the U.S. Pacific populations (NMFS and USFWS 1998) of hawksbill sea turtles, for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in these recovery plans:

- Identify important nesting beaches;
- Ensure long-term protection and management of important nesting beaches;
- Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties, and breakwaters;
- Identify important marine habitats; protect and manage populations in marine habitat;
- Protect and manage marine habitat; prevent the degradation or destruction of important (marine) habitats caused by upland and coastal erosion;
- Prevent the degradation of reef habitat caused by sewage and other pollutants;
- Monitor nesting activity on important nesting beaches with standardized index surveys;
- Evaluate nest success and implement appropriate nest-protection on important nesting beaches;
- Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation; and
- Determine nesting beach origins for juveniles and sub-adult populations.

4.2.9 Kemp's Ridley Turtle

The Kemp's ridley sea turtle was first listed under the Endangered Species Conservation Act and has been listed as endangered under the ESA since 1973. Its range includes the entire Gulf of America and U.S. Atlantic coast, with nesting beaches limited to a few sites in Mexico and Texas (Figure 30).

Life History

Females mature at 12 years of age. The average remigration interval is two years. Nesting occurs from April to July in large arribadas, primarily at Rancho Nuevo, Mexico. Females lay an average of 2.5 clutches per season. The annual average clutch size is 97 to 100 eggs per nest. The nesting location may be particularly important because hatchlings can more easily migrate to foraging grounds in deeper oceanic waters, where they remain for approximately two years before returning to nearshore coastal habitats. Juvenile Kemp's ridley turtles use these nearshore coastal habitats from April through November, but move towards more suitable overwintering habitat in deeper offshore waters (or more southern waters along the Atlantic coast) as water

temperature drops. Adult habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 37 m deep, although they can also be found in deeper offshore waters. As adults, Kemp's ridley turtles forage on swimming crabs, fish, jellyfish, mollusks, and tunicates (NMFS et al. 2011).

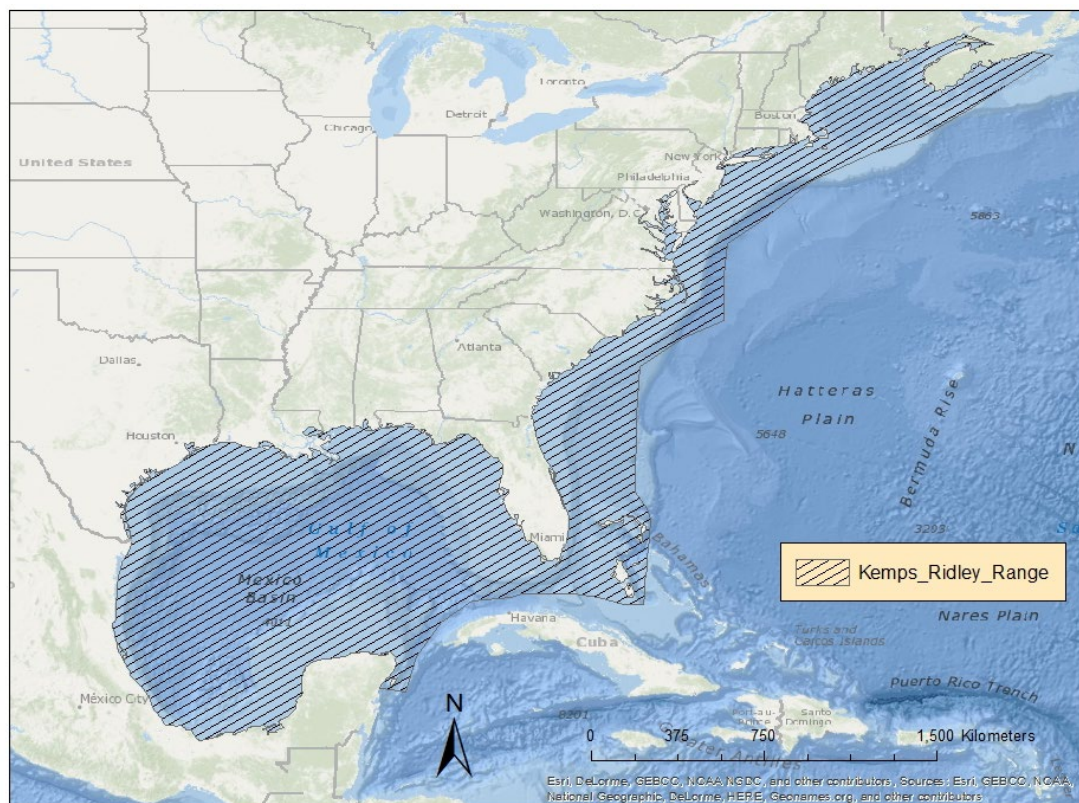


Figure 30. Map Identifying the Range of the Endangered Kemp's Ridley Sea Turtle

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distributions as it relates to the Kemp's ridley sea turtle.

Of the sea turtle species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. In 2009, the total number of nests recorded at Rancho Nuevo and adjacent beaches exceeded 20,000, which represents about 8,000 females nesting during the nesting season. The number of nests in Padre Island, Texas has increased over the past several decades, from one nest observed in 1985, four in 1995, 50 in 2005, 101 in 2015, and 137 in 2023 (NMFS and USFWS 2015; NPS 2024). From 1980 through 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15% annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival of immature and

adult sea turtles, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2015). In 2014, there were an estimated 10,987 nests and 519,000 hatchlings released from three primary nesting beaches in Mexico (NMFS and USFWS 2015). Since females lay approximately 2.5 nests each season they nest, 10,987 nests represents 4,395 females nesting in a season at these primary nesting sites.

DiMatteo et al. (2024) modeled survey data to estimate in-water abundance of juvenile and adult Kemp's ridley sea turtles (> 40 cm) along the U.S. Atlantic Coast. Mean Kemp's ridley abundance was 10,762 (90% CI 2,620–19,443). Monthly predicted abundance ranged from a high of 13,220 in October to a low of 8,341 in August, but only varied by a few thousand animals from month to month. Predicted density was high off southern Georgia and northern Florida year-round. Kemp's ridley turtles were predicted to be in the Mid-Atlantic from May until November, generally from Chesapeake Bay north to Delaware Bay, and as far north as Long Island Sound in summer months (DiMatteo et al. 2024).

Genetic variability in Kemp's ridley turtles is considered to be high, as measured by heterozygosity at microsatellite loci (NMFS et al. 2011). Additional analysis of the mitochondrial DNA taken from samples of Kemp's ridley turtles at Padre Island, Texas showed six distinct haplotypes, with one of these also being found at Rancho Nuevo (Dutton et al. 2006).

The Kemp's ridley turtle occurs from the Gulf of America and along the Atlantic coast of the U.S. (TEWG 2000). Kemp's ridley turtles have occasionally been found in the Mediterranean Sea, which may be due to migration expansion or increased hatchling production (Tomas and Raga 2008). The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of America coast of Mexico. From nesting beaches in the Gulf of America, the migratory corridor traverses neritic areas of the Mexico and U.S. Gulf coasts from late May through August with a peak in June (Shaver et al. 2016). During spring and summer, juvenile Kemp's ridley turtles occur in the shallow coastal waters along the Atlantic continental shelf from New England to Florida, and from the northern Gulf of America from Texas to north Florida. In the fall, most Kemp's ridley turtles migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998). As adults, many sea turtles remain in the Gulf of America, with only occasional occurrence in the Atlantic Ocean (NMFS et al. 2011).

Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Juvenile Kemp's ridley turtles can hear from 100 to 500 Hz, with a maximum sensitivity between 100 to 200 Hz at thresholds of 110 dB re: 1 μ Pa (Bartol and Ketten 2006). More details can be found in the sea turtle acoustic and explosive effects analyses section below (Section 6.2.1).

Status

The Kemp's ridley turtle was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances prohibited the harvest of sea turtles in Mexico from May to August, and in 1990, the harvest of all sea turtles was prohibited by presidential decree. In 2002, Rancho Nuevo was declared a sanctuary. A successful head-start program has resulted in re-establishment of nesting in Texas, and nest counts show an upward trend at Padre Island since the 1980's. While fisheries bycatch remains a threat, the required use of sea turtle excluder devices in many fisheries mitigates take. Fishery interactions and strandings, possibly due to forced submergence, appear to be the main threats to the species. While the Kemp's ridley population shows sign of steadily increasing, the species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness. Therefore, the specie's resilience to future perturbation is considered low.

Critical Habitat

No critical habitat has been designated for Kemp's ridley turtles.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover Kemp's ridley turtle populations. These threats are discussed in further detail in the *Environmental Baseline* section of this opinion. The following items were identified as priorities to recover Kemp's ridley turtles:

- Protect and manage nesting and marine habitats;
- Protect and manage populations on the nesting beaches and in the marine environment;
- Maintain a stranding network;
- Manage captive stocks;
- Sustain education and partnership programs;
- Maintain, promote awareness of and expand U.S. and Mexican laws;
- Implement international agreements; and
- Enforce laws.

See the 2011 Final Bi-National (U.S. and Mexico) Revised Recovery Plan for Kemp's ridley turtles for complete downlisting/delisting criteria for each of their respective recovery goals (NMFS and USFWS 2011).

4.2.10 Leatherback Sea Turtle

Leatherback sea turtles are listed as endangered under the ESA throughout their global range. The leatherback turtle has the most extensive global distribution of any reptile and is distributed throughout the oceans of the world (Figure 31) from the equator to subpolar regions in both hemispheres. Leatherback turtles spend the majority of their lives at sea, where they develop, forage, migrate, and mate, nesting on beaches on every continent except Europe and Antarctica,

and several islands of the Caribbean and the Indo-Pacific (Eckert et al. 2012; NMFS and USFWS 2020b). Seven populations are currently recognized: (1) Northwest Atlantic; (2) Southeast Atlantic; (3) Southwest Atlantic; (4) Northeast Indian; (5) Southwest Indian; (6) West Pacific; and (7) East Pacific Ocean populations (NMFS and USFWS 2020b). For purposes of this opinion, we focus on the Northwest Atlantic population.

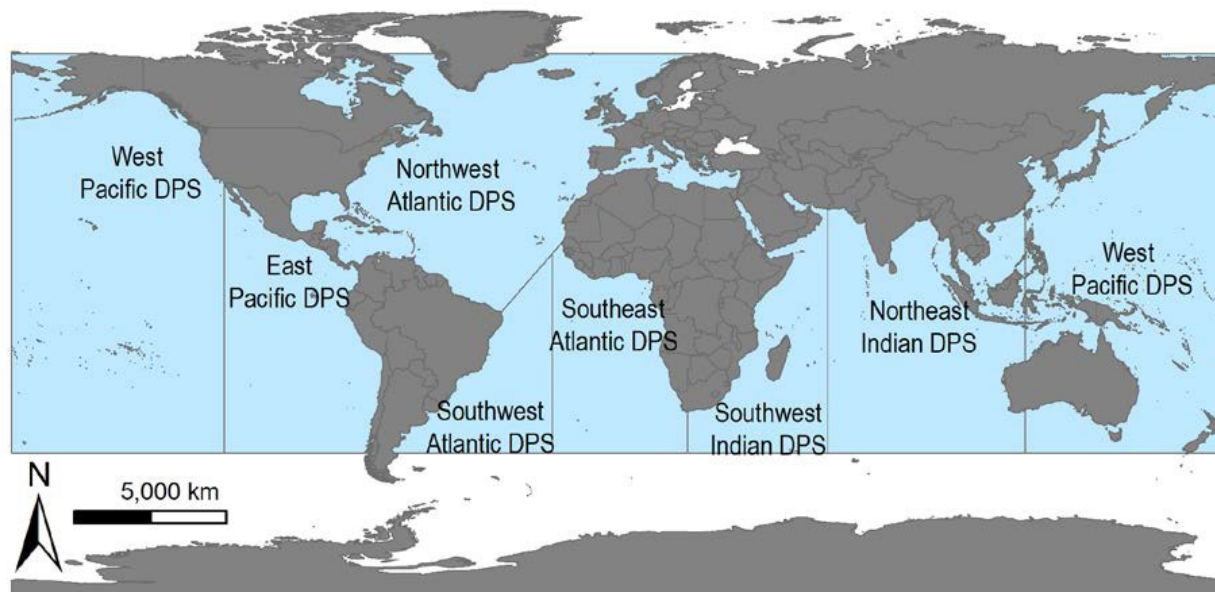


Figure 31. Leatherback Sea Turtle DPS Boundary Map (NMFS and USFWS 2020b)

Life History

Age at maturity has been difficult to ascertain, with estimates ranging from 5 to 29 years (Spotila et al. 1996; Avens et al. 2009). Females lay up to 7 clutches per season, with more than 65 eggs per clutch (Reina et al. 2002; Wallace et al. 2007). The average clutch frequency based on data from Northwest Atlantic nesting beaches is 5.5 clutches per season (NMFS and USFWS 2020b). The number of leatherback turtle hatchlings that make it out of the nest on the beach (i.e., emergent success) is approximately 50% worldwide (Eckert et al. 2012). Females nest every 1 to 7 years. Leatherback sea turtles undertake the longest migrations of any sea turtle, migrating long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage. During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 15 ft of the surface (Eckert 2002).

Leatherback turtles primarily feed on gelatinous zooplankton such as cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas) (Bjorndal 1997; USFWS 1998). These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight and energetic needs. Leatherback sea turtles feed from near the surface to depths exceeding 1,000 m, including nocturnal feeding on tunicate colonies within the deep scattering layer (Spotila 2004). Although leatherback sea turtles can dive deeper than any

other reptile, most foraging dives are less than 80 m (Shillinger et al. 2011). Leatherback turtles weigh about 33% more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Aguirre et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

Population Dynamics

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

Sea turtles are difficult to study across all life stages due to their extensive distribution, certain cryptic life stages, complex life history, and remote habitats. As a result, status and trends of sea turtle populations are usually based on data collected on nesting beaches (e.g., number of adult females, number of nests, nest success, etc.). The spatial structure of male sea turtles and their fidelity to specific coastal areas is unknown; however, we describe the status of sea turtle populations based on the nesting beaches that females return to when they mature. We make inferences about the growth or decline of leatherback populations based on numbers of nests and trends in numbers of nests.

Based on the best available data, the total index of nesting female abundance for the leatherback Northwest Atlantic DPS is 20,659 females (NMFS and USFWS 2020b). The total index of nesting female abundance for this DPS only includes available nesting data from recently and consistently monitored nesting beaches, and assumes a 3-year remigration interval. Nesting in the Northwest Atlantic population is characterized by many small nesting beaches. Only one site, Grande Riviere in Trinidad, hosts more than 5,000 nesting females, representing 29% of the total index of nesting female abundance. Relatively large nesting aggregations are also found in Matura (Trinidad), Chiriqui Beach (Panama), and Cayenne/Remire Montjoly (French Guiana) (NMFS and USFWS 2020b). There are no leatherback nesting sites located within the action area for this opinion.

Although nesting trends vary by site, the leatherback Northwest Atlantic population appears to exhibit an overall decreasing trend in annual nesting activity (NMFS and USFWS 2020b). This conclusion is supported by significant declines that have been observed at nesting beaches with the greatest historical or current nesting female abundance, most notably in Trinidad and Tobago (Grande Riviere, Fishing Pond, and Tobago), Suriname, and French Guiana (Awala-Yalimapo). The NALWG (2018) used a Bayesian regression model to estimate trends for all nesting sites, nesting aggregations, and for the regional population (which is equivalent to DPS) during three temporal scenarios: 1990-2017, 1998-2017, and 2008-2017. Overall nest trends were as follows:

- From 1990 to 2017: -4.21% annually (95% CI = -6.66 to -2.23)
- From 1998 to 2017: -5.37% annually (95% CI = -8.09 to -2.61)

- From 2008 to 2017: -9.32% annually (95% CI = -12.9 to -5.57)

DiMatteo et al. (2024) modeled survey data to estimate in-water abundance of leatherback sea turtles (> 40 cm) along the U.S. Atlantic Coast. Mean leatherback abundance was 21,984 (90% CI 10,049–33,600). Monthly predicted abundance ranged from a high of 54,329 in September to a low of 4,655 in February and was generally higher in warm months and lower in cool months. Leatherback turtles were predicted to be off the coast of Georgia and Florida year-round (DiMatteo et al. 2024). This seasonal abundance pattern is supported by the sightings data and may reflect the East Coast's importance as a nesting and migratory habitat, but not as a foraging habitat, as turtles from the wider Caribbean region migrate to the north Atlantic Ocean basin seasonally to forage.

The Northwest Atlantic leatherback population has a broad spatial distribution, for both foraging and nesting. There is significant genetic population structure, with subpopulations connected via various levels of gene flow and metapopulation dynamics (NMFS and USFWS 2020b). Tagging and telemetry studies indicate considerable mixing of leatherback turtles among nesting beaches and at multiple foraging areas throughout the North Atlantic. The spatial distribution and structure of the Northwest Atlantic population likely reduces the risk of extinction (NMFS and USFWS 2020b). The wide distribution of nesting and foraging areas likely buffers this population against local catastrophes or environmental changes. The fine-scale population structure, with movement of individuals and genes among nesting aggregations, indicates that this population has the capacity to withstand other catastrophic events.

The Northwest Atlantic population exhibits spatial diversity, as demonstrated by insular and continental nesting, diverse foraging habitats, multiple foraging areas, and moderate genetic diversity. Diverse nesting location and habitat provide the population some level of resilience against short-term spatial and temporal changes in the environment; however, high-abundance nesting occurs only at few locations (e.g., Trinidad, French Guiana, and Panama) (NMFS and USFWS 2020b). The foraging diversity likely provides resilience against local reductions in prey availability or catastrophic events, such as oil spills, by limiting exposure to a limited proportion of the total population. Its moderate genetic diversity may provide the Northwest Atlantic population with the raw material necessary for adapting to long-term environmental changes (NMFS and USFWS 2020b).

Rider et al. (2024) studied leatherback movement and migratory behavior along the U.S. Atlantic coast based on satellite transmitter data from 52 leatherbacks tagged between 2017 and 2022 off the coasts of Massachusetts and North Carolina. Their results indicated that leatherbacks were primarily foraging in Southern New England between Nantucket and Long Island Sound and that foraging was occurring throughout the entire water column. In the Mid-Atlantic Bight, foraging related behavior was concentrated between Cape Hatteras, North Carolina, and the mouth of Delaware Bay during the summer. There was also evidence of foraging in the South Atlantic Bight along the coast as well as along the continental shelf edge. This study suggests that there are important leatherback foraging grounds in the South and Mid-Atlantic Bights, in addition to

the well-known northern foraging areas off Southern New England and Nova Scotia (Rider et al. 2024). In the Gulf of America, main foraging sites include the northeast corner from Louisiana to Florida, the coastal shelf of southwest Florida, and eastern side of Campeche Bay (Aleksa et al. 2018).

Vocalization and Hearing

Little is known about sea turtle sound use and production. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300 to 500 Hz (Cook and Forrest 2005; Mrosovsky 1972). These sounds are thought to be associated with breathing (Cook and Forrest 2005; Mrosovsky 1972).

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Piniak (2012) measured hearing of hatchlings leatherback turtles in water and in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz and 1.6 kHz in air and between 50 Hz and 1.2 kHz in water (lowest sensitivity recorded was 93 dB re: 1 μ Pa at 300 Hz). More details can be found in the sea turtle acoustic and explosive effects analyses section below (Section 6.2.1).

Status

The primary global threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Additional threats to the Northwest Atlantic leatherback population include habitat loss, predation, disease, vessel strike, pollution, changing environmental conditions, oil and gas activities, natural disasters, and channel dredging. Coastal development and shoreline armoring, erosion (natural and anthropogenic), and artificial lighting are some of the most significant stressors on nesting beach habitat, reducing nesting and hatching success (productivity). Habitat loss is also anticipated to increase over time with additional development and changing environmental conditions. Changing environmental conditions may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise). Plastic ingestion is also common in leatherbacks and can block gastrointestinal tracts leading to death. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance.

This Northwest Atlantic leatherback population exhibits a decreasing nest trend that has become more pronounced in recent years (i.e., 2008-2017), and the available nesting data reflect a steady decline for more than a decade (Group 2018; NMFS and USFWS 2020b). Despite the population's abundance, spatial distribution, and diversity, the declining nest trends and productivity are of concern and place the Northwest Atlantic leatherback population's continued persistence in question. Overall, the latest 5-year status review concluded that the Northwest Atlantic leatherback population has a high extinction risk (NMFS and USFWS 2020b).

Critical Habitat

Leatherback sea turtle designated critical habitat does not overlap with the action area or any stressors resulting from the proposed action.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover leatherback turtle populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. The following items were the top five recovery actions identified to support in the Leatherback 5-Year Action Plan:

- Reduce fisheries interactions.
- Improve nesting beach protection and increase reproductive output.
- International cooperation.
- Monitoring and research.
- Public engagement

See the 1992 Recovery Plans for the U.S. Caribbean, Atlantic, and Gulf of Mexico leatherback turtles for complete downlisting/delisting criteria for each of their respective recovery goals (NMFS and USFWS 1992).

4.2.11 Loggerhead Sea Turtle – Northwest Atlantic Ocean DPS

Loggerhead turtles are circumglobal and are found in the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans. The species was first listed as threatened under the ESA in 1978 (43 FR 32800). On September 22, 2011, NMFS designated nine DPSs of loggerhead turtles, including the Northwest Atlantic Ocean DPS, which is ESA-listed as threatened. Northwest Atlantic Ocean DPS of loggerhead turtles are found along eastern North America, Central America, and northern South America (Figure 32).

Life History

Mean age at first reproduction is 36 to 38 years for females and 37 to 42 years for males. Adults migrate to the waters off their natal beach to mate. Females nest every one to seven years and exhibit relatively strong nest-site fidelity (Shamblin et al. 2017). The average remigration interval is 2.7 years. They nest one to seven times in a season, with an interesting interval of approximately 14 days. Clutch sizes range from 95 to 130 eggs, with an incubation duration of 42 to 75 days (NMFS and USFWS 2023). Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Nesting females of the Northwest Atlantic DPS prefer steeply sloped, coarse-grained beaches prone to high rates of erosion (Lamont and Houser 2014). Nesting begins in April, peaks in June or July, and ends in August or September (NMFS and USFWS 2023). Temperature determines the sex of the sea turtle during the middle of the incubation period. Mayne et al. (2020) estimated the average maximum lifespan of loggerhead turtles to be 62.8 years (± 3.7 years).

After emerging from their nests at night, hatchlings crawl seaward using visual cues, toward the brighter horizon of the open ocean and away from the dark, elevated silhouettes of dunes and vegetation (Pankaew and Milton 2018). After hatchlings enter the sea, they begin a 24 to 36-hour swim frenzy, orienting into waves to reach offshore currents (DuBois et al. 2021). Loggerhead sea turtles spend the post-hatchling stage in pelagic waters. Post-hatchling loggerheads are primarily associated with consolidated patches of floating material, especially *Sargassum spp.*, which becomes concentrated in the Gulf of America and especially along the western wall of the Gulf Stream (Witherington et al. 2012a).



Figure 32. Northwest Atlantic Ocean DPS of Loggerhead Sea Turtle Range

The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). While in their oceanic phase, loggerhead turtles undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground. Loggerhead turtle hatchlings from the western Atlantic Ocean disperse widely, most likely using the Gulf Stream to drift throughout the Atlantic Ocean. Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerhead turtles. Neritic juvenile loggerheads forage on crabs, mollusks, jellyfish and vegetation, where as adults typically prey on benthic invertebrates such as mollusks and decapods.

Population Dynamics

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

There is a general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage. Vandeperre et al. (2019) found that relative abundance of loggerheads in the Azores tracked annual nest abundance at source rookeries in Florida when adjusted for a 3-year lag. This concurrence of abundance patterns indicates that recruitment to the oceanic stage is more dependent on nest abundance at source rookeries than on stochastic processes derived from short term climatic variability (Vandeperre et al. 2019).

An overall estimate of nesting females for the Northwest Atlantic Ocean DPS is not available because of reproductive parameter uncertainty: remigration intervals and clutch frequencies vary spatially and temporally, and data are insufficient for some recovery units (NMFS and USFWS 2023). Based on available nest count data in U.S. from Texas through Virginia and Quintana Roo, Mexico, the DPS hosts more than 110,000 nests annually.

Based on genetic information, the Northwest Atlantic Ocean DPS of loggerhead turtle is further categorized into five recovery units corresponding to nesting beaches. These are the Northern Recovery Unit, Peninsular Florida Recovery Unit, Dry Tortugas Recovery Unit, Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit. Adequate loggerhead nesting data are available from the Northern and the Peninsular Florida recovery units, which combined represent 89% of nesting within the DPS (Ceriani and Meylan 2017). Using the average annual number of loggerhead nests between 2014 and 2018, Ceriani et al. (2019) estimated the total number of adults females nesting in Florida to be 51,319.

The annual rate of increase for the Northern Recovery Unit, based on nesting females and measured over the period from 1983-2019, is positive 1.3% ($p=0.04$) (Bolten et al. 2019; NMFS and USFWS 2023). There is no significant trend in the annual number of nesting females in either the Peninsular Florida (1989-2018) or Northern Gulf of Mexico (1997-2018) units over the last several decades (NMFS and USFWS 2023). Lasala et al. (2023) reported a significant increase in loggerhead nest counts and hatchling production from 1982 to 2021 based on data covering a 50.9 km stretch of Florida's Gulf of America coastline (Sarasota County). Similarly, McNally et al. (2024) reported a significant increase in loggerhead nest counts in Pinellas County from 1990 to 2022. While these data indicate a positive trend for at least some nesting beaches within the Peninsular Florida recovery unit, the total nesting count in the Gulf of America annually accounts for only 7% of all loggerhead nesting in Florida (Lasala et al. 2023). The Dry Tortugas Recovery Unit includes all islands west of Key West, while the Greater Caribbean Recovery Unit encompasses nesting sub-populations in Mexico to French Guiana, the Bahamas, and the Lesser and Greater Antilles. Data are insufficient to estimate trends in nesting females for either the Dry Tortugas or the Greater Caribbean recovery units. Overall, the latest

five-year status review concluded that the DPS as a whole demonstrates a stable (neither increasing nor decreasing) population trend (NMFS and USFWS 2023).

DiMatteo et al. (2024) modeled survey data to estimate in-water abundance of juvenile and adult loggerhead sea turtles (> 40 cm) along the U.S. Atlantic Coast. Mean loggerhead abundance was 193,423 (90% CI = 159,158–227,668). Monthly predicted abundance ranged from a high of 245,609 in February to a low of 135,066 in September, and was generally higher in cool months and lower in warm months.

Juvenile loggerheads commonly forage in nearshore coastal waters, coastal inlets, sounds, bays, estuaries, lagoons, and along the continental shelf during spring, summer, and fall months from Cape Cod, south to Florida, and into the Gulf of America. During winter they are found off the coast from North Carolina to Florida. Subadult and adult loggerhead turtles tend to inhabit deeper offshore feeding areas along the western Atlantic coast, from mid-Florida to New Jersey.

Overall, the DPS demonstrates relatively low genetic diversity, especially for its population size, which may reduce its resilience to environmental changes (NMFS and USFWS 2023).

Mitochondrial DNA evidence demonstrates that juvenile loggerhead turtles from southern Florida nesting beaches comprise the vast majority (71–88%) of individuals found in foraging grounds throughout the western and eastern Atlantic Ocean: Nicaragua, Panama, Azores and Madeira, Canary Islands and Adalusia, Gulf of America, and Brazil (Masuda 2010). Chow et al. (2019) conducted the first genome-wide genetic assessment of loggerheads using 45 neritic-stage loggerheads captured from the South Atlantic Bight and Florida Bay. They found relatively low genome-wide genetic diversity, which may indicate a past bottleneck.

An analysis using expanded mitochondrial DNA sequences revealed that rookeries from the Gulf and Atlantic coasts of Florida are genetically distinct, and that rookeries from Mexico's Caribbean Sea coast express high haplotype diversity (Shamblin et al. 2014). conducted skeletal growth mark analysis (skeletochronology) for 123 humerus bones collected from loggerheads found dead in the US Gulf of America from 1998 to 2021. Avens et al. (2025) compared age, growth, and maturation data from loggerheads found in the Gulf of America from 1998 to 2021 with similar data for Atlantic coast loggerheads. Their results indicate that Gulf of America loggerheads exhibit significantly faster juvenile somatic growth and smaller size at maturation, corresponding with mean estimates of age at maturation 7.5 to 15 years earlier than Atlantic loggerheads. The maximum observed Gulf of America adult age estimate was 42.5 years, considerably less than the highest Atlantic estimate of 77.0 years (Avens et al. 2025).

Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999) reported the effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: 1 μ Pa and two-year olds: about 86 dB re: 1 μ Pa), with threshold increasing rapidly above

and below that frequency (Bartol and Ketten 2006). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead turtle (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re: 1 μ Pa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to 1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014). More details can be found in the sea turtle acoustic and explosive effects analyses section below (Section 6.2.1).

Status

The greatest threat to the DPS is fisheries bycatch, which results in the death of thousands of turtles annually. Habitat modification is a major threat that is further exacerbated by changing environmental conditions. Other ongoing threats that reduce the abundance of adults and large juveniles include vessel strikes, legal and illegal harvest, egg poaching, predation, disease, dredging, and power plants.

The five recovery units provide spatial and genetic diversity to the DPS, which increases its likelihood of persistence via metapopulation dynamics (i.e., losses at one subpopulation may be buffered by gains at another). However, the vast majority of nesting (89%) occurs within the Peninsular Florida recovery unit, whose average annual growth rate is not significantly different from zero (NMFS and USFWS 2023). The NMFS and USFWS 2023 5-year status review (NMFS and USFWS 2023) for the Northwest Atlantic Ocean DPS concluded that none of the following three demographic criteria for recovery have been met: 1) number of nests and number of nesting females; 2) trends in abundance on foraging grounds; and 3) trends in neritic strandings relative to in-water abundance.

Critical Habitat

See Section 4.1.3 Loggerhead Sea Turtle – Northwest Atlantic DPS Designated Critical Habitat.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover loggerhead sea turtle populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. The following items were identified as priorities to recover the loggerhead Northwest Atlantic Ocean DPS:

- Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females;
- Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes;
- Manage sufficient nesting beach habitat to ensure successfully nesting;
- Manage sufficient feeding, migratory, and interesting marine habitats to ensure successful growth and reproduction;

- Eliminate legal harvest;
- Implement scientifically based nest management plans;
- Minimize nest predation;
- Recognize and respond to mass/unusual mortality or disease event appropriately;
- Develop and implement local, state, Federal, and international legislation to ensure long-term protection of loggerhead sea turtles and their terrestrial and marine habitats;
- Minimize bycatch in domestic and international commercial and artisanal fisheries;
- Minimize trophic changes from fishery harvest and habitat alteration;
- Minimize marine debris ingestions and entanglement; and
- Minimize vessel strike mortality.

See the 2008 Final Recovery Plan for the Northwest Atlantic Population of Loggerheads (NMFS and USFWS 2008) for complete downlisting/delisting criteria for each of the following recovery objectives.

4.2.12 Atlantic Salmon – Gulf of Maine DPS

The Gulf of Maine DPS of anadromous Atlantic salmon was initially listed by USFWS and NMFS as an endangered species on November 17, 2000 (65 FR 69459). A subsequent rule issued by the Services expanded the geographic range for the Gulf of Maine DPS of Atlantic salmon (June 19, 2009; 74 FR 29344). The Gulf of Maine DPS of Atlantic salmon is defined as all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, and wherever these fish occur in the estuarine and marine environment (Figure 33). The marine range of the Gulf of Maine DPS extends from the Gulf of Maine, throughout the Northwest Atlantic Ocean, to the coast of Greenland. Included in the Gulf of Maine DPS are all associated conservation hatchery populations used to supplement these natural populations; currently, such conservation hatchery populations are maintained at Green Lake National Fish Hatchery (GLNFH) and Craig Brook National Fish Hatcheries (CBNFH), both operated by the USFWS, as well as private watershed-based facilities (Downeast Salmon Federation's East Machias and Pleasant River facilities). Excluded from the Gulf of Maine DPS are landlocked Atlantic salmon and those salmon raised in commercial hatcheries for the aquaculture industry. Coincident with the June 19, 2009 endangered listing, NMFS designated critical habitat for the Gulf of Maine DPS of Atlantic salmon (74 FR 29300).

We used information available in the status review (USFWS 2020), recent scientific publications to summarize the life history, population dynamics and status of the species and the most up to date science and data on Atlantic salmon originated from the 2024 Atlantic Salmon Assessment Committee Report (Hawkes 2024) .

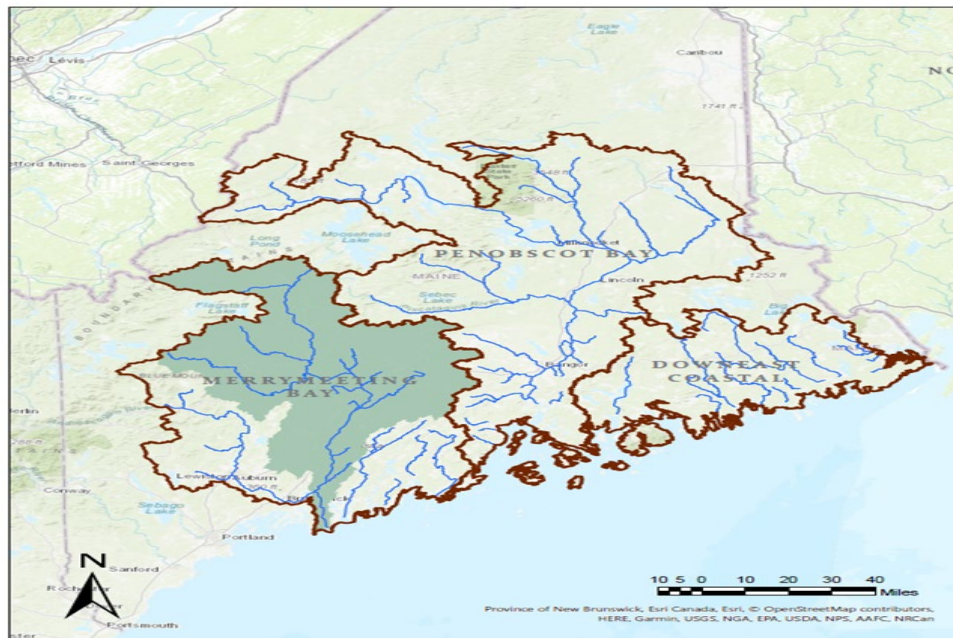


Figure 33. Gulf of Maine DPS for Atlantic Salmon with the Three Recovery Units Identified (Kennebec River Watershed is shown in green)

Life History

Adult Atlantic salmon typically spawn in early November and juveniles spend about two years feeding in freshwater until they weigh approximately two ounces and are six inches in length. Smoltification (the physiological and behavioral changes required for the transition to salt water) usually occurs at age two for Gulf of Maine DPS Atlantic salmon. Gulf of Maine DPS Atlantic salmon migrate more than 4,000 km in the open ocean to reach feeding areas in the Davis Strait between Labrador and Greenland. The majority of Gulf of Maine DPS Atlantic salmon (about 90%) spend two winters at sea before reaching maturity and returning to their natal rivers, with the remainder spending one or three winters at sea. At maturity, Gulf of Maine DPS Atlantic salmon typically weigh between 8 to 15 lbs and average 30 inches in length.

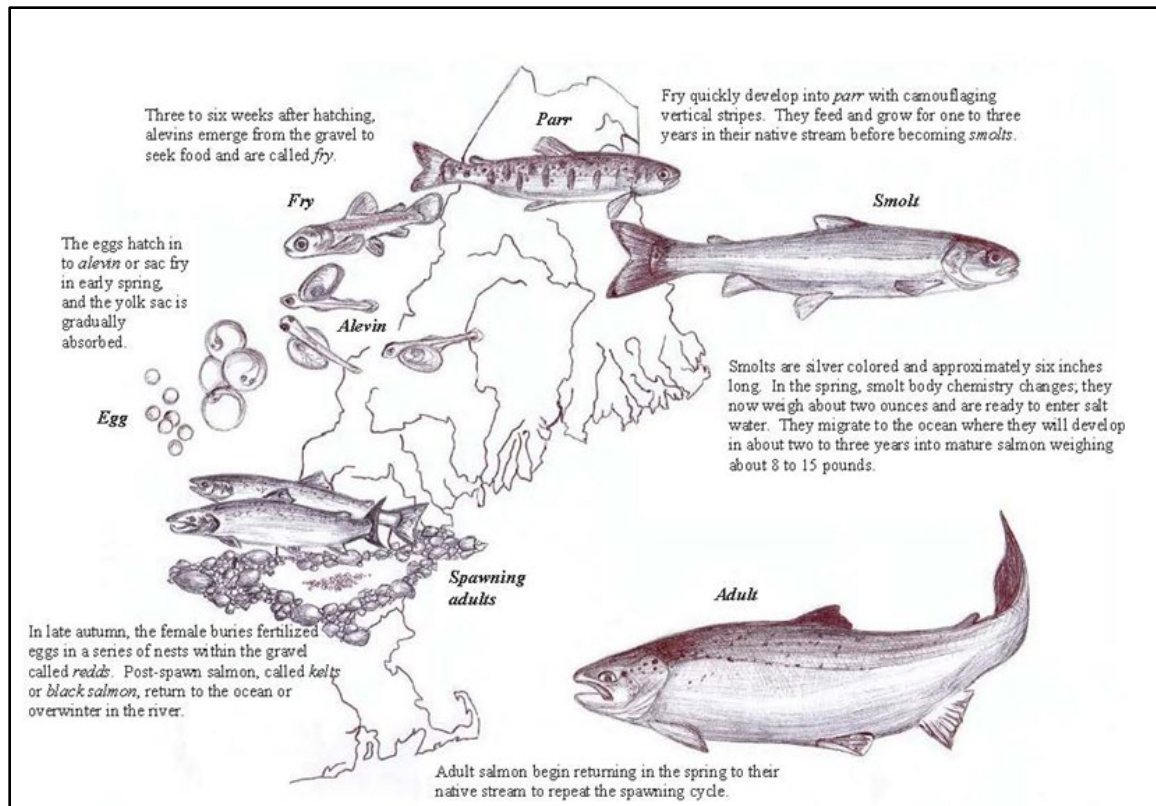


Figure 34. Life Cycle of the Atlantic salmon (diagrams courtesy of Katrina Mueller)

Population Dynamics

Comparing monitored adult abundance to management targets is an instructive metric of overall stock health. The number of returning Atlantic salmon needed to utilize fully all juvenile rearing habitats is termed the Conservation Limit (CL). The CL for the Gulf of Maine DPS is 29,198 adults (Baum 1995). In 2024, Atkinson et al (2024) provided an update of the CL for U.S. populations considering updated habitat estimates, sex ratios and fecundity values. The updated estimate was delineated by DPS and critical versus non-critical habitat. The CL for Gulf of Maine DPS critical habitat is estimated at 22,134 returns. However, considering ongoing efforts to improve and update habitat area values conservation target reporting will remain unchanged in this document and remain 29,198. The values presented by Atkinson et al (2024) may be considered more fully in the future and are available and can be used for river-specific management targets in the interim.

Conservation Limit targets represent long-term goals for sustainable population sizes. Given the endangered status of the Gulf of Maine DPS, the current recovery plan target for down listing from endangered to threatened is at least 1,500 adults originating from wild origin, or hatchery stocked eggs, fry, or parr spawning in the wild, with at least 2 of the 3 SHRUs having a minimum annual escapement of 500 naturally-reared adults. The threshold of 2,000 wild spawners per SHRU, totaling 6,000 wild spawners annually for the Gulf of Maine DPS, is one of the current recovery targets needed to consider delisting from endangered species listing. As such, adult returns are partitioned into hatchery returns (adult salmon that are a product of an

accelerated smolt program or released as fall parr or fall fingerlings) or naturally-reared returns (products of natural spawning, egg planting, and fry stocking).

Estimates of effective population size, based on 18 loci, vary both within broodstocks over time, and between broodstocks. Estimates are obtained using the linkage disequilibrium method that incorporates bias correction found in Ne Estimator (V2.01, Do et al. 2013). Estimates are based on the minimum allele frequency of 0.010, and confidence intervals are generated by the jackknife option. Parr-based broodstocks typically incorporate a single year class, thereby not violating assumptions for effective population size estimates of overlapping generations. Within the parr-based broodstocks, the lowest N_e from the 2021 collection year was estimated for the Dennys broodstock ($N_e = 50.9$, 41.3-63.1 95% CI), and the highest was observed in the Narraguagus broodstock ($N_e = 99.4$ (79.3-127.5 95% CI). N_e estimates fluctuate annually. Beginning in 2008, average N_e across the parr-based broodstocks ranges from $N_e = 68.9$ in the Dennys to $N_e = 134.3$ in the Narraguagus. Within the Penobscot River, adult broodstocks typically include three to four year classes (including grilse). N_e estimates for the Penobscot since 2008 have ranged from maximum $N_e = 546.5$ (465.8-650.7 95% CI) in 2017 to the low $N_e = 287.6$ in 2009 (265.7-312.0 95% CI), with an average $N_e = 402.4$. The N_e estimate for the 2023 return the broodstock falls below the average, $N_e = 308.3$ (276.1-345.7 95% CI). The N_e estimate for the 2020 Penobscot domestic year class (collected from juveniles from a single year class) is $N_e = 120.4$ in (105.9-136.7 95% CI).

Status

The Gulf of Maine DPS of Atlantic salmon currently exhibits critically low spawner abundance, poor marine survival, and is confronted with a variety of additional threats. The abundance of Gulf of Maine DPS Atlantic salmon has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is small and displays little sign of growth. The most recent 5-year review for the species concluded the following:

- The demographic risks to Atlantic salmon remain high. The three SHRUs have 10-year average abundance of less than 100 natural spawners per SHRU. Of the eight locally adapted populations that remain in the Gulf of Maine DPS, seven are supported by conservation hatcheries that act to buffer extinction risk. The eighth, the Ducktrap River, is at very high risk of extirpation. With naturally reared populations being very low, the geometric mean population growth rates have been, as can be expected, highly variable. Given the high degree of variability in the population growth rates and the very low population abundances of naturally reared fish, we will need to continue to monitor population trajectories very carefully (NMFS and USFWS, 2020).

The spatial distribution of the Gulf of Maine DPS has been severely reduced relative to historical distribution patterns due to the construction of dams. The conservation hatchery program assists in slowing the decline and helps stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the Gulf of Maine DPS. Although the hatchery program is critical, it alone cannot recover the species. Recovery of the Gulf of Maine DPS must be

accomplished through increases in naturally reared salmon, which will only occur if the ongoing threats to the species (as defined in the 2019 Recovery Plan) are abated. This can be accomplished by improving connectivity at dams and road stream crossings, and through projects that improve freshwater habitat productivity.

Critical Habitat

On June 19, 2009, NMFS and the U.S. Fish and Wildlife Service designated critical habitat for Atlantic salmon (74 FR 29300). There is no overlap between Gulf of Maine Atlantic salmon critical habitat and the action area for this opinion.

Recovery Goals

The USFWS and NMFS issued a recovery plan (“Recovery Plan”) for Atlantic salmon on February 12, 2019 (USFWS and NMFS 2019). The Recovery Plan presents a recovery strategy based on the biological and ecological needs of the species as well as current threats and conservation accomplishments that affect its long-term viability. The Recovery Plan is based on two premises: first, that recovery must focus on rivers and estuaries located in the Gulf of Maine DPS until the Services have a better understanding of the threats in the marine environment, and second, that survival of Atlantic salmon in the Gulf of Maine DPS will be dependent on conservation hatcheries through much of the recovery process. In addition, the scientific foundation for the plan includes conservation biology principles regarding population viability, an understanding of freshwater habitat viability, and threats abatement needs.

The Gulf of Maine DPS is divided into three Salmon Habitat Recovery Units (SHRUs) (74 FR 29300, June 19, 2009). The three SHRUs are the Downeast Coastal SHRU, Penobscot Bay SHRU, and Merrymeeting Bay SHRU. The SHRU delineations were designed to: 1) ensure that a recovered Atlantic salmon population has widespread geographic distribution to help maintain genetic variability; and 2) provide protection from demographic and environmental variation. A widespread distribution of salmon across the three SHRUs will provide a greater probability of population sustainability in the future, which will be needed to achieve recovery of the Gulf of Maine DPS.

As described in the Recovery Plan, reclassification of the Gulf of Maine DPS from endangered to threatened will be considered when all of following criteria are met:

- Abundance: The DPS has total annual returns of at least 1,500 naturally reared adults (i.e., originating from spawning in the wild, or from hatchery stocked eggs, fry or parr), with at least two of the three SHRUs having a minimum annual escapement of 500 naturally reared adults;
- Productivity: Among the SHRUs that have met or exceeded the abundance criterion, the population has a positive mean growth rate greater than 1.0 in the 10-year (two-generation) period preceding reclassification; and,

- Habitat: In each of the SHRUs where the abundance and productivity criterion have been met, there is a minimum of 7,500 units¹⁴ of accessible and suitable spawning and rearing habitats capable of supporting the offspring of 1,500 naturally reared adults.

As described in the Recovery Plan, the delisting criteria are:

- Abundance: The DPS has a self-sustaining annual escapement of at least 2,000 wild origin adults in each SHRU, for a DPS-wide total of at least 6,000 wild adults;
- Productivity: Each SHRU has a positive mean population growth rate of greater than 1.0 in the 10-year (two-generation) period preceding delisting. In addition, at the time of delisting, the DPS demonstrates self-sustaining persistence, whereby the total wild population in each SHRU has less than a 50-percent probability of falling below 500 adult wild spawners in the next 15 years based on population viability analysis (PVA) projections; and
- Habitat: Sufficient suitable spawning and rearing habitat for the offspring of the 6,000 wild adults is accessible and distributed throughout the designated Atlantic salmon critical habitat, with at least 30,000 accessible and suitable habitat units in each SHRU, located according to the known migratory patterns of returning wild adult salmon. This will require both habitat protection and restoration at significant levels.

In 2020, NMFS and USFWS completed a 5-year review that evaluated whether any of these reclassification criteria had been achieved. The review concluded that the demographic risks to Atlantic salmon are still high, that the number of naturally reared or wild adults is still less than 100 per SHRU, and that the primary threats have not been sufficiently abated. As such, the review indicated that none of the above criteria had been achieved; and therefore did not recommend any change to the classification of the Gulf of Maine DPS of Atlantic salmon (NMFS and USFWS 2020a).

4.2.13 Atlantic Sturgeon

Five separate DPSs of Atlantic sturgeon were listed under the ESA by NMFS effective April 6, 2012 (77 FR 5880 and 5914, February 6, 2012). The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs were listed as endangered and the Gulf of Maine DPS was listed as threatened. Sturgeon are among the most primitive of the bony fishes. They can grow to approximately 14 ft long and can weigh up to 800 lbs. Atlantic sturgeon are bluish-black or olive brown dorsally (on their back) with paler sides, a white belly, and have five major rows of dermal "scutes".

This section starts with general information on the Atlantic sturgeon coast-wide population. The subsections that follow provide information and characteristics particular to each of the five ESA-listed DPSs of Atlantic sturgeon.

¹⁴ One habitat unit equals 100 m².

Life History

Atlantic sturgeon are long-lived, late-maturing, estuarine-dependent, anadromous fish distributed along the eastern coast of North America, as shown in Figure 35 (Waldman and Wirgin 1998). Historically, sightings have been reported from Hamilton Inlet, Labrador, Canada, south to the St. Johns River, Florida (Murawski and Pacheco 1977; Smith and Clugston 1997). While adult Atlantic sturgeon from all DPSs mix extensively in marine waters, Atlantic sturgeon return to their natal rivers to spawn approximately 96% of the time (Kazyak et al. 2021). Genetic studies show that fewer than two adults per generation spawn in rivers other than their natal river (Wirgin et al. 2000; Waldman et al. 2002). Young sturgeon spend the first few years of life in their natal river estuary before moving out to sea (Waldman et al. 2002). The Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 of them. Individuals are currently present in 36 rivers, and spawning occurs in at least 20 of these (ASSRT 2007).

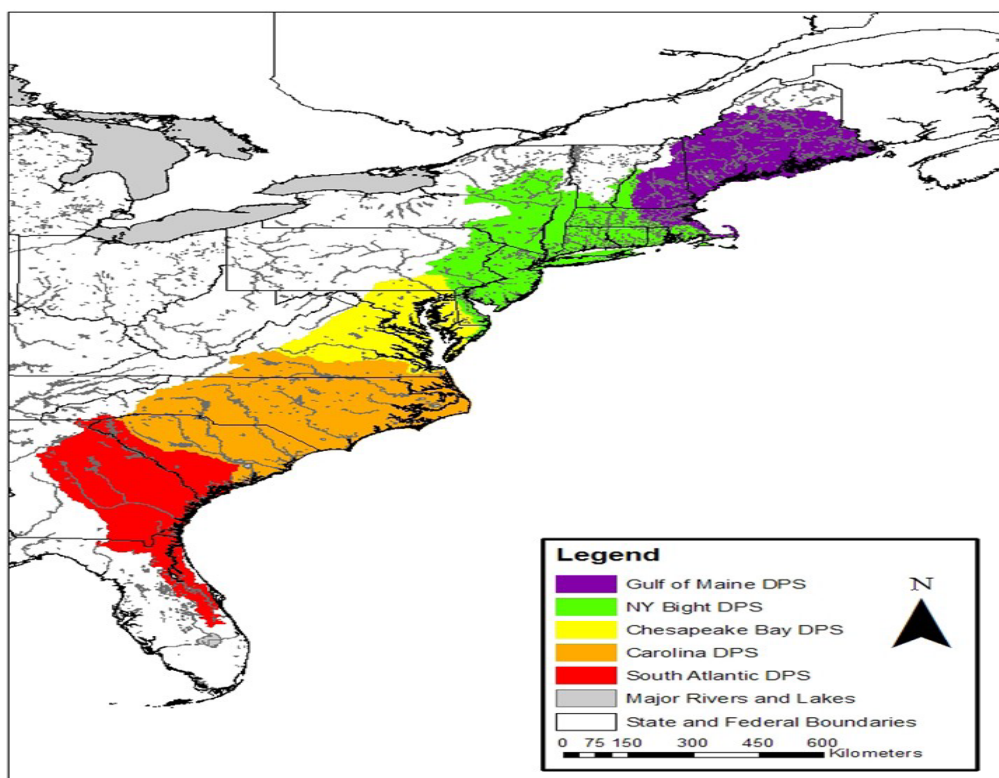


Figure 35. Range and Boundaries of the Five Atlantic Sturgeon DPSs.

This section provides general information on the Atlantic sturgeon coast-wide population, including information about the species life history, population dynamics, and status. The subsections that follow provide information and characteristics particular to each of the five ESA-listed DPSs of Atlantic sturgeon.

Range-wide Population Ocean Abundance Estimate

An Atlantic sturgeon range-wide (i.e., all DPSs) population estimate was derived from the NEAMAP trawl surveys, which have been conducted (spring and fall) since fall 2007 from Cape

Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 60 ft (18.3 m) across 150 stations. For this Opinion, we are relying on the population estimates derived from the NEAMAP swept area biomass assuming a 50% catchability (i.e., net efficiency x availability) rate. We consider that the NEAMAP surveys sample an area utilized by Atlantic sturgeon but do not sample all the locations and times where Atlantic sturgeon are present. We also consider that the trawl net captures some, but likely not all, of the Atlantic sturgeon present in the sampling area. Therefore, we assume that net efficiency and the fraction of the population exposed to the NEAMAP surveys in combination result in a 50% catchability (NMFS 2013b). The 50% catchability assumption reasonably accounts for the robust, yet not complete, sampling of the Atlantic sturgeon oceanic temporal and spatial ranges and the documented high rates of encounter with NEAMAP survey gear. As these estimates are derived directly from empirical data with fewer assumptions than have been required to model Atlantic sturgeon populations to date, we believe these estimates continue to serve as the best available information.

Based on the above approach, the overall abundance of Atlantic sturgeon in U.S. Atlantic waters is estimated to be 67,776 fish (Kocik et al. 2013). Based on genetic frequencies of occurrence in the sampled area, this overall population estimate was subsequently partitioned by DPS (Table 45). Given the proportion of adults to subadults in the NMFS Northeast Fisheries Science Center observer data (approximate ratio of 1:3), we have also estimated the number of adults and subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size that are present and vulnerable to capture in commercial trawl and gillnet gear in the marine environment.

Table 45. Calculated Atlantic Sturgeon Population Estimates Based upon the NEAMAP Survey Swept Area Model, Assuming 50% Efficiency

Atlantic Sturgeon DPS	Estimated Ocean Population Abundance	Estimated Ocean Population of Adults	Estimated Ocean Population of Subadults (of size vulnerable to capture in fisheries)
Gulf of Maine	7,455	1,864	5,591
New York Bight	34,566	8,642	25,925
Chesapeake Bay	8,811	2,203	6,608
Carolina	1,356	339	1,017
South Atlantic	14,911	3,728	11,183

Canada	678	170	509

It is important to note, the NEAMAP-based estimates do not include young-of-the-year (YOY) fish and juveniles in the rivers; therefore, the NEAMAP-based estimates underestimate the total population size as they do not account for multiple year classes of Atlantic sturgeon that do not occur in the marine environment where the NEAMAP surveys take place. The NEAMAP surveys are conducted in waters that include the preferred depth ranges of subadult and adult Atlantic sturgeon and take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. However, the estimated number of subadults in marine waters is a minimum count because it only considers those subadults that are captured in a portion of the action area and are present in the marine environment, which is only a fraction of the total number of subadults. In regards to adult Atlantic sturgeon, the estimated population in marine waters is also a minimum count as the NEAMAP surveys sample only a portion of the action area, and therefore a portion of the Atlantic sturgeon's range.

Vocalization and Hearing

Sturgeon are known to produce sounds, especially during spawning. Lake sturgeon produce low frequency sounds during spawning bouts, principally consisting of drumming sounds that range from 5 to 8 Hz, but low frequency rumbles and hydrodynamic sounds as well as high frequency sounds have also been reported (Bocast et al. 2014). The pallid sturgeon (*Scaphirhynchus albus*) and shovelnose sturgeon (*Scaphirhynchus platyrhynchus*) are known to produce at least four types of sounds during the breeding season, ranging from squeaks and chirps from 1 to 2 kHz, with low frequency moans ranging in frequency between 90 and 400 Hz (Johnston and Phillips 2003). Based on these related sturgeon species, we assume Atlantic sturgeon are capable of producing both low and high frequency sounds, mostly likely during the breeding season.

While sturgeon have swim bladders, they are not known to be used for hearing, and thus sturgeon appear to only rely directly on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz, indicating that sturgeon should be able to localize or determine the direction of origin of sound. Meyer and Popper (2002) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for Oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon were more similar to goldfish (which is considered a hearing specialist that can hear up to five kHz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing (Meyer and Popper 2002). Lovell et al. (2005) also studied sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that

paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of all DPSs of Atlantic sturgeon.

Critical Habitat

See Section 4.1.3 Atlantic Sturgeon Designated Critical Habitat above.

Recovery Goals

A recovery outline for Atlantic sturgeon was developed in 2018. This outline is meant to serve as an interim guidance document to direct recovery efforts, including recovery planning, for the endangered New York Bight, Chesapeake Bay, Carolina, and South Atlantic distinct population segments (DPS) of the Atlantic sturgeon and the threatened Gulf of Maine DPS (77 FR 5880 and 77 FR 5914; February 6, 2012) until a full recovery plan is developed and approved.

For the Gulf of Maine, New York Bight, and Chesapeake Bay DPSs, historical spawning habitat is accessible in nearly all current and known historical spawning rivers. This is not the case for the Carolina and South Atlantic DPSs of Atlantic sturgeon. Within the range occupied by the Carolina DPS, dams have restricted Atlantic sturgeon spawning and juvenile developmental habitat by blocking over 60% of the historical sturgeon habitat upstream of the dams in the Cape Fear and Santee-Cooper River systems. Dams also prevent access to the vast majority of historical spawning habitat on the Savannah River in the South Atlantic DPS.

The recovery vision for the Atlantic sturgeon is to ensure sub-populations making up all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and that increased recruitment must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future.

The Atlantic States Marine Fisheries Commission (ASMFC) completed an Atlantic Sturgeon Benchmark Stock Assessment in 2017 that considered the status of each DPS individually, as well as all 5 DPSs collectively as a single unit (ASMFC 2017). The assessment concluded all five DPSs of Atlantic sturgeon, as well as each individual DPS remain depleted relative to historic abundance. The assessment also concluded that the population of all five DPSs together appears to be recovering slowly since implementation of a complete moratorium in 1998. However, while the survival estimates produced by the stock assessment were based on telemetry data, the conclusions that abundance was increasing was not supported by any underlying data. There was a relatively high probability that mortality for animals of the Gulf of Maine DPS and the Carolina DPS exceeded the mortality threshold used for the assessment.

Kazyak et al. (2021) classified North Carolina and, therefore, the action area in the MID region, individual-based assignment tests suggested a highly mixed assemblage of Atlantic sturgeon from all five DPSs which included 14 populations from across the U.S. and Canada (the only population not represented in the sample was the Saint Lawrence). Individual-based assignment testing suggested 37.5% of individuals assigned to populations in the New York Bight DPS and 30.7% of individuals to populations in the Carolina DPS. At the population-level, the Albemarle Complex (27.3%) and Hudson River (26.2%) populations were the most prevalent specimen sampled in this region. However, all DPSs were represented in the samples collected. Kazyak et al. (2021) also observed differences in the stock composition of individuals captured in riverine/estuarine habitats versus offshore ($P < 0.001$ at both the population- and DPS-level). Of the individuals captured in the MID region in riverine/estuarine environments, 60.9% assigned to the Carolina DPS. Conversely, only 6.0% of individuals captured offshore assigned to the Carolina DPS, and individuals from the New York Bight (54.0%) and Chesapeake Bay DPSs (21.6%) were more prevalent. Results from the mixture analysis were similar and also suggested that samples collected offshore likely represented individuals from more populations and DPSs than samples collected in riverine/estuarine environments.

The recovery priority numbers for the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs is 1C based on the Listing and Recovery Priority Guidelines (84 FR 18243, April 30, 2019). This number is based on the following criteria: demographic risk, recovery potential, and conflict. Demographic risk is “High” because of its productivity (i.e., relatively few adults compared to historical levels and irregular spawning success), abundance (i.e., riverine populations vary significantly and abundance is generally low in the DPS’, overall), and spatial distribution (i.e., riverine populations and connectivity vary, creating inconsistent population coverage across the DPSs and potentially limited ability to repopulate extirpated river populations). Meeting any one of these risk conditions ranks the DPSs as at high demographic risk. The DPSs potential to recover is, however, also “High” because man-made threats that have a major impact on the species’ ability to persist have been identified (e.g., bycatch in federally-managed fisheries, dams blocking access to spawning habitat, dredging, vessel strikes), the DPS’ response to those threats are well understood, management or protective actions to address major threats are primarily under U.S. jurisdiction or authority, and management or protective actions are technically feasible even if they require further testing (e.g., gear modifications to minimize dredge or fishing gear interactions). The DPSs are in conflict with construction and other developmental projects such as port deepening projects. Therefore, based on the Listing and Recovery Priority Guidelines (84 FR 18243, April 30, 2019), the recovery priority number for the Atlantic sturgeon DPSs is 1C, and is unchanged since listing and the last status review of Atlantic sturgeon.

Gulf of Maine DPS

The Gulf of Maine DPS of Atlantic sturgeon was listed as threatened on February 6, 2012. The Gulf of Maine DPS historically supported at least four spawning subpopulations; however, today

it is suspected that only two extant subpopulations exist (Penobscot and Kennebec rivers) (ASSRT 2007). The geomorphology of most small coastal rivers in Maine is not sufficient to support Atlantic sturgeon spawning populations, except for the Penobscot and the estuarial complex of the Kennebec, Androscoggin, and Sheepscot rivers. Although surveys have not been conducted to document Atlantic sturgeon presence, subadults may use the estuaries of the smaller coastal drainages (i.e., St. Croix, Machias and Saco rivers) during the summer months (MSPO 1993; ASSRT 2007).

The Kennebec River is the primary spawning and nursery area for Gulf of Maine Atlantic sturgeon. Ripe female Atlantic sturgeon with enlarged, fully mature eggs ready to be fertilized have been found in the Kennebec River from mid-July through early August (MSPO 1993). Historical records indicate that the major spawning area for Atlantic sturgeon in the Kennebec River was above head-of-tide between Augusta and Waterville. Prior to any commercial fishing, the Kennebec supported approximately 10,000-15,000 spawning adults (MSPO 1993; ASSRT 2007). The construction of the Edwards Dam at river kilometer (rkm) 64 in 1837 was believed to have caused the commercial sturgeon catch to decline over 50% (MSPO 1993). Severe pollution in the river from the 1930's through the early 1970's is believed to have been a major factor in the continued decline of the sturgeon population in the Kennebec. In 2007, the ASSRT concluded that, due to stressors related to poor water quality, dredging, and commercial bycatch, there was a moderate risk (i.e., < 50% chance) of the Kennebec subpopulation of Atlantic sturgeon becoming endangered within the next 20 years.

An open population estimate of marine-oriented Atlantic sturgeon (sub-adult and adult) foraging in the Saco River from May to November is between 1,400 and 6,800 individuals annually (Flanigan et al. 2021). The Kennebec River effective population size and 95% confidence limits (CL) were estimated at 67.0 (52.0-89.1) and 79.4 (60.3-111.7) by Waldman et al. (2019); n = 62) and White et al. (2021b); n = 48). Effective population size is essentially an estimate of the number of breeding individuals in a population required to maintain the amount of genetic variability observed within samples from that population. Furthermore, two larval Atlantic sturgeon were captured just above the Kennebec River estuary between 24 and 25 °C in mid-July, confirming successful reproduction in this location (Wippelhauser et al. 2017). It is thought the Penobscot may have historically supported a spawning population, but it is possibly extirpated (ASMFC 2017). Wippelhauser et al. (2017) suggests Atlantic sturgeon use the upper Kennebec River, the Kennebec River estuary, and the Androscoggin River estuary for reproduction. It is unknown whether the Merrimack River supports a reproductive population of Atlantic sturgeon (ASMFC 2017). And while the Androscoggin represents an additional known spawning location for this DPS, non-spawning individuals were observed to use the Penobscot, Androscoggin, Saco, Merrimack, St. John, and Minas Passage (Altenritter et al. 2017; Novak et al. 2017; Wippelhauser et al. 2017). Survival rates of all ages is estimated to be approximately 74% annually (95% confidence limits, 15-99%; ASMFC 2017). The ASSRT concluded that the Penobscot subpopulation also had a moderate risk of becoming endangered due to its potentially small size (likely less than 300 spawning adults), increased dredging projects, and poor water quality (ASSRT 2007). Within the Penobscot, substrate has been severely degraded by upstream

mills, and water quality has been negatively affected by the presence of coal deposits and mercury hot spots. The potential for commercial bycatch was also viewed as a moderate threat to this subpopulation due to its small size.

New York Bight DPS

The New York Bight DPS was listed as endangered under the ESA on February 6, 2012. The New York Bight, ranging from Cape Cod to the Delmarva Peninsula. The Connecticut, Hudson, and Delaware Rivers all support reproductive populations while the Taunton River population appears to be extirpated. A recent assessment of relatedness of these populations to others along the coast reveals, as was the case at the time of listing, that the Hudson and Delaware populations appear to be a separate group from other populations but also different from one another (White et al. 2021a). The Connecticut River was not included in that study. A recent study using acoustic telemetry to estimate spawning duration and return intervals shows that Hudson River adults return much more frequently than previously thought; females every 1.66 years and males every 1.28 years (Breece et al. 2021). This is in agreement with recent studies conducted in the York River (Hager et al. 2020), both suggesting females, in particular, spawn more often than previously thought. In the Hudson River, males were on spawning grounds on average from May 27 through July 11 and females from June 8 through June 29. The average male is also more likely to travel further upriver than the average female (Breece et al. 2021).

There are a number of abundance estimates for each river. The Hudson River most likely supports the largest population of Atlantic sturgeon in the United States. Effective population estimates for the Hudson River are 156 (95% CL, 138.3-176.1; $n = 459$; Waldman et al. (2019) and 145.1 (82.5-299.4; $n = 307$; White et al. (2021a). Kazyak et al. (2020) produced an abundance estimate of the 2014 adult spawning run size of 466 individuals (95% CL, 310-745). While this spawning run size is nearly identical to that estimated by Kahnle et al. (2007), monitoring of relative abundance of juveniles from 2004 through 2019 has shown production may have doubled during those 16 years (Pendleton and Adams 2021).

In the Delaware River, the effective population size has been estimated to be 40 (95% CL, 34.7-46.2; $n = 108$) and 60.4 (42-85.6; $n = 488$) by Waldman et al. (2019) and White et al. (2021a), respectively. The significant difference between estimates is likely due to sample size. Therefore, White et al. (2021a) estimate is likely most accurate. Additionally, a recent close-kin mark-recapture estimate was produced for the Delaware River and suggests there are fewer than 250 adults (census) in the Delaware River population (White et al. 2021a).

In the Connecticut River, despite only limited collection of juvenile sturgeon ($n = 47$), there is an estimate of effective population size of two (95% CL, 2-2.7; Waldman et al. 2019). This would suggest there has been a single spawning event in the Connecticut River that produced all of the juvenile fish collected or the spawning adults were so closely related as to be indistinguishable from a single pair. Either way, it is clear there is limited genetic diversity in this population and, unless these adults continue returning to the Connecticut River, it could take approximately 20 years to learn whether these juveniles have survived in sufficient numbers to sustain this new population.

Recent survival estimates do not suggest much of an improvement since the last estimates made during the commercial fishery (Boreman 1997; Kahnle et al. 1998). Melnychuk et al. (2017) provided an updated estimate of survival of Hudson River Atlantic sturgeon of approximately 88.22%, while for similar life stages over a longer time frame, ASMFC (2017) estimated survival of the entire New York Bight to be 91% (95% confidence limits, 71-99%).

The range of Atlantic sturgeon can be measured from north to south or inshore to offshore. While there has been no change to the range along the East Coast, there are detection data of acoustic transmitters much further offshore than had previously been documented.

To understand movement along the coast, White et al. (2021b) assessed the river of origin of Atlantic sturgeon harvested during the commercial fishery. This was a duplication of a study done by Waldman et al. (1996), but showed fish harvested in the Hudson River were from many locations other than the Hudson. The makeup of the harvested fish in the 1990s was 82.3% Hudson, 7.3% Delaware, 4.7% James River spring run, 2.4% St. Lawrence, 2.1% Kennebec, 1.3% Pee Dee spring run, rather than 98% Hudson as had been estimated during the fishery. The reasons for the difference are likely a more thorough baseline consisting of 18 known populations rather than only nine (White et al. 2021a) and the use of microsatellite DNA rather than mitochondrial. However, Wirgin et al. (2018) sampling 148 sub-adult sturgeon in the Hudson River estuary and relying on microsatellite DNA, found 142 of those were of Hudson River origin with additional contributions from the Kennebec (2), Delaware (2), Ogeechee (1), and James (1) Rivers. This may suggest adults are more likely to enter estuaries than sub-adults.

In terms of nearshore habitat use, Breece et al. (2018) showed habitat selection is driven by depth, time of year, sea surface temperature, and light absorption by seawater, while sex and natal river do not seem to be important predictors of habitat selection. Therefore, regardless of the makeup of the mixed populations in these estuarine areas, the drivers of where the fish are located affect all sexes and populations similarly. Inshore and offshore movement is highly dependent on photoperiod and temperature, with fish residing offshore from November to January and inshore from June to September (Ingram et al. 2019). Fish gradually move inshore from February to May but rapidly move offshore during October (Ingram and Peterson 2018; Ingram et al. 2019). In the Delaware Bay, when fish have moved inshore for the spring and summer months, Breece et al. (2018) showed Atlantic sturgeon prefer shallow water and warmer bottom temperatures primarily in the eastern portion of the bay during residency but that this preference changes to deep, cool water and the western edge of the bay during migration.

Kazyak et al. (2021) studied the offshore composition of sturgeon between Cape Hatteras and Cape Cod (Mid-Atlantic, which comprises the New York Bight, Chesapeake Bay, and part of the Carolina DPSs) and found that 37.5% and 30.7% of all bycaught fish in this region were from the New York Bight and Carolina DPSs, respectively. This was primarily driven by 27.3% of fish from the Albemarle complex and 26.2% from the Hudson River. Estuarine bycatch in this area was primarily from Albemarle Complex, with many of the samples being obtained in waters of North Carolina, and most offshore fish were from the Hudson and James Rivers.

Chesapeake Bay DPS

The Chesapeake Bay DPS was listed as endangered under the ESA on February 6, 2012. Historically, Atlantic sturgeon were common throughout the Chesapeake Bay and its tributaries (Kahnle et al. 1998, Wharton 1957, Bushnoe et al. 2005). Based on U.S. Fish Commission landings data, approximately 20,000 adult female Atlantic sturgeon inhabited the Chesapeake Bay and its tributaries prior to development of a commercial fishery in 1890 (Secor 2002). Chesapeake Bay rivers once supported at least six historical spawning subpopulations (ASSRT 2007), but today reproducing populations are only known to occur in the James and York Rivers. However, the presence of telemetry tagged Atlantic sturgeon in freshwater portions of Chesapeake Bay tributaries during the summer/fall spawning season (late July to mid-October) suggests that spawning may also occur in the Rappahannock, Potomac, Nanticoke, and Pocomoke Rivers.

There are only three known spawning populations for this DPS in the James, York, and Nanticoke Rivers. Edwards et al. (2020) noted an adult male Atlantic sturgeon was detected at the saltwater interface of the Patuxent River, which may indicate potential spawning. However, Kahn et al. (2019) noted that telemetry detections are not a meaningful indicator of whether a male is spawning. Because males are often in spawning condition during non-spawning situations Van Eenennaam et al. (1996), even if this individual had been captured and observed in spawning condition, that would not have been enough to suggest spawning was occurring in the Patuxent River.

The James River supports the largest population of Atlantic sturgeon within the DPS. Balazik et al. (2012a) reported empirical evidence that James River Atlantic sturgeon spawn in the fall. As noted above, a more recent study also indicates that Atlantic sturgeon also spawn in the spring in the James River (i.e., dual spawning races) (Balazik and Musick 2015). Genetic analysis of tissue samples suggest effective populations in the James River range from around 40 to 100 (O'Leary et al. 2014). The ASSRT concluded that the James River had a moderately high risk (> 50% chance) of becoming endangered in the next 20 years, due to anticipated impacts from commercial bycatch. Dredging and ship strikes were also identified as threats (i.e., moderate risk) that contribute to the risk of extinction for the James subpopulation of Atlantic sturgeon.

The York River has a much smaller population, with annual spawning abundance estimates for 2013 of 75 (Kahn et al. 2014). The effective population size of the York River population ranges from 6 to 12 individuals, the smallest effective population size for any Atlantic sturgeon subpopulation along the Atlantic Coast. The total York River adult Atlantic sturgeon abundance is estimated at 289 individuals. The highest ranked stressor for the York River was commercial bycatch, which received a moderate risk rank (ASSRT 2007).

Monitoring in the York River reveals that males return to spawn every 1.13 years and females every 2.19 years (Hager et al. 2020). Males in the Nanticoke River system return to spawn every 1.68 years (calculated from Table 2 in Secor et al. 2022) but there is insufficient information to estimate female return intervals. Hager et al. (2020) shows spawning in the York River occurs on descending temperatures from 25.1 °C to 21.5 °C. This narrow temperature window is bounded

by increased egg mortality at 25 °C and peak bioenergetic growth around 22 °C. Similarly, Secor et al. (2022) shows adults present on Nanticoke River spawning grounds from 26.7 °C down to 17.8 °C with most fish leaving the system by 20 °C. Spawning in both systems appears to be driven by temperature and photoperiod with a peak of spawning around the autumn equinox (Hager et al. 2020; Secor et al. 2022). Sex ratios when spawning range from approximately 64 to 75% male in the York River, though the overall population appears to be approximately 51% male (95% CL, 43-58%; (Kahn 2019).

A recent assessment of relatedness of all Atlantic sturgeon populations showed that, when all populations along the coast are grouped, the James River (spring and fall runs) is most closely related to rivers in the northeast, while the York River is most closely related to rivers in the southeast (White et al. 2021a). The York River population was distinct when compared to those southeastern rivers; the James River, meanwhile, when compared to northeastern rivers, remains closely related to a group of rivers in Canada and Maine but is differentiated from the Hudson and Delaware Rivers. At this point in the analysis, Program COLONY (a computer program to estimate likelihood of genealogical relationships from genotype data), which was used to estimate closeness of relationships, could have identified three clusters (James spring and fall, Hudson and Delaware, and Maine/Canada), but did not. When compared only with rivers from Maine and Canada (White et al. 2021a), the James River spring and fall runs both appear to be unique but can be further separated from each other when compared to one another (Balazik et al. 2017b; White et al. 2021a). This analysis shows that the York River population (and Nanticoke River population, which appear to form an upper Chesapeake Bay metapopulation [J. Kahn, NMFS, unpublished data]) is significantly different from the two James River populations at the most basic level of comparison.

Considerable advances have been made in understanding the abundance of each of these populations. There are no estimates of abundance for any life stage in the James River. The York River has estimates of adult abundance on spawning runs from 2014 through 2019 (Table 46). Census estimates of adult Atlantic sturgeon on spawning runs in the Nanticoke River in 2020 and 2021 are 36 (25-55) and Coleman et al. (2024) estimated the Nanticoke River adult spawning run abundance is up to approximately 70 individuals. Effective population size of the James River (as a single spawning population) was estimated from 116 samples to be 32 (28.8-35.5; Waldman et al. (2019) and White et al. (2021a) assessed the James River spring (n = 45) and fall (n = 131) spawning adults separately and identified effective population sizes of 24.7 (21-29.4) and 85.5 (61.1-127.5), respectively. The lone effective population estimate for the York River (n = 203) is 9.3 (6.9-11.8; (White et al. 2021a) and for the Nanticoke River (n = 32) is 12.2 (6.7-21.9; (Secor et al. 2022).

Table 46. Estimated Abundance of Spawning Runs in the Pamunkey River, the Primary Spawning Tributary of the York River

Year	Male*	Female*	Spawning abundance*	95% CL*	Jackknife model**	95% CL†
2014	117	41	158	127-189	152	115-215
2015	125	68	192	154-230	182	145-243
2016	112	38	149	120-179	219	166-298
2017	150	68	218	175-260	215	167-292
2018	92	30	122	98-145	154	112-222
2019	153	86	239	192-286	330	257-434

* Estimates from Kahn et al. (2021); ** Estimates from (Kahn 2019); jackknife is a statistical cross-validation technique using resampling, useful for variance estimation.

Several recent survival estimates have been produced. At the DPS level, the Chesapeake Bay DPS is estimated to have an apparent annual survival of approximately 88% (95% CL, 46-99%; ASMFC 2017). A recent estimate for adult York River Atlantic sturgeon by Kahn et al. (2023) shows much higher survival than other estimates with an annual apparent survival of 99.2% (97.9-99.7%). Kahn et al. (2023) estimate was higher because it accounted for different detection probabilities between sexes and identified tag loss rates of 12.8% through concurrent mark recapture research.

Oceanic distribution of the Chesapeake Bay DPS is best known from the analysis by Kazyak et al. (2021). This is the same information as presented for the New York Bight DPS because both populations occupy waters between Cape Hatteras and Cape Cod. Rothermel et al. (2020), like Ingram et al. (2019), noted an inshore movement in the spring and offshore movement in the fall and winter. And, like Breece et al. (2018) observed, Atlantic sturgeon appear to prefer warmer, shallower water while residing offshore.

A recovery outline was produced for Atlantic sturgeon (NMFS 1998a). The goal for recovery is to have reproductive populations across their historic range of sufficient size and diversity to support reproduction and recovery from mortality events. The invasive blue catfish has become a more notable threat to native fish in the Chesapeake Bay region. A recent analysis of stomach contents reveals that 22 of 560 fish sampled (4%) comprising 27 species consumed Atlantic sturgeon during the fall spawning period (Bunch et al. 2021). The primary consumers of Atlantic sturgeon were striped bass (1 of 8 guts, 12.5%), carp (6 of 52 guts, 11.5%), and blue catfish (8 of 131 guts, 6%). No hard parts were present and the assumption is that the Atlantic sturgeon DNA was either from eggs or larvae that were quickly digested (Bunch et al. 2021).

Carolina DPS

The Carolina DPS was listed as endangered under the ESA on February 6, 2012. The Carolina DPS ranges from the Albemarle Sound to the Santee-Cooper River and consists of seven extant subpopulations; one subpopulation (Sampit) is believed to be extirpated. The Carolina DPS is likely the least studied. Spawning likely occurs in the Roanoke, Tar/Pamlico, Neuse, Cape Fear, Pee Dee, Santee, and Cooper Rivers. Census abundance is not available for any system. The effective population size of juveniles collected in the Albemarle Sound is approximately 19 (95% CL, 16.5-20.6; $n = 88$; Waldman et al. 2019) to 29.5 (24.2-36.3; $n = 71$; White et al. 2021a). The effective population size estimate for the Pee Dee River spring ($n = 66$) and fall ($n = 50$) spawning runs, amounting to 13.5 (11.9-15.3) and 82 (60.3-122.1), respectively (White et al. 2021a; White et al. 2021b). Denison et al. (2025) used side-scan sonar to estimate the abundance of dual-spawning (i.e., spring and fall) Atlantic sturgeon in the Great Pee Dee River, South Carolina. The estimated maximum weekly abundance of spawning adult Atlantic sturgeon in the study area was 587 (95% CI = 328–1,085) and 875 (95% CI = 511–1,607) individuals during the spring and fall spawning runs, respectively (Denison et al. 2025). Also, updating Hightower et al. (2015), the ASMFC (2017) produced an updated survival estimate for the entire Carolina DPS, suggesting Atlantic sturgeon survival rates are approximately 78% (95% CL, 39-99%).

Relatedness of known spawning populations was also assessed for the Carolina DPS, both in terms of its relationships to other populations outside of the DPS and within. Once the York River is isolated as being unique and different from all other southeastern populations, those populations then break into two groups with a bit of overlap. One group is the Albemarle Complex, Pee Dee spring run, Pee Dee fall run, Edisto spring run, Ogeechee spring run, and Satilla river populations while the other group is the Albemarle Complex, Pee Dee fall run, Edisto fall run, Savannah, Ogeechee fall run, and Altamaha populations (White et al. 2021a). When compared amongst each other further, those groupings break out into the Albemarle Complex, Pee Dee spring run, and Pee Dee fall run separate from the rest of the southeastern rivers (White et al. 2021a).

As mentioned in the discussion of the New York Bight DPS sturgeon distribution, the Carolina DPS made up 30.7% of detections between Cape Cod and Cape Hatteras. This DPS also makes up 6.2% of detections south of Cape Hatteras (Kazyak et al. 2021). From Cape Cod to Florida, Carolina DPS fish were most likely to be encountered in nearshore waters. Rulifson et al. (2020), relying on acoustic telemetry, showed that, similar to what has been documented for New York Bight and Chesapeake Bay DPS fish, Carolina DPS sturgeon move inshore and offshore seasonally. The greatest number of detections along the North Carolina Atlantic Coast occur from November to April (Rulifson et al. 2020). The Stock Assessment estimated the mean survival rates of 78%, 33%, and 72% for all acoustically tagged fish, acoustically tagged adults, and acoustically tagged juveniles from the Carolina DPS, respectively. The ASMFC also concluded it was relatively likely (75% probability) that mortality for the Carolina DPS exceeds the mortality threshold used for the Stock Assessment (ASMFC 2017).

South Atlantic DPS

The South Atlantic DPS was listed as endangered under the ESA on February 6, 2012. This DPS historically supported eight spawning subpopulations but currently supports five extant spawning subpopulations (ASSRT 2007). At the time of listing only six spawning subpopulations were believed to have existed: the Combahee River; Edisto River; Savannah River; Ogeechee River; Altamaha River (including the Oconee and Ocmulgee tributaries); and Satilla River. Of these subpopulations, the Altamaha and Ashepoo, Combahee, and Edisto (ACE) Basin support the largest number of spawning adults, and are considered the second and third largest Atlantic sturgeon subpopulations within the United States, respectively

The Edisto and Ogeechee Rivers appear to have a spring and a fall run (White et al. 2021a). When exploring the possibility of spring and fall spawning migrations, without any knowledge of the reproductive condition of the individuals, Vine et al. (2019) identified temperature as a primary driver of upriver movement in both the spring and fall. In the spring, Atlantic sturgeon moved upriver as temperatures increased between 11 and 15 °C and in the fall, as temperatures were descending, between 29 and 24 °C (Vine et al. 2019). For Atlantic sturgeon, discharge did not influence upriver movement (Vine et al. 2019).

In 2017, the ASMFC completed an Atlantic Sturgeon Benchmark Stock Assessment (ASMFC 2017). The purpose of the assessment was to evaluate the status of Atlantic sturgeon along the U.S. Atlantic coast (ASMFC 2017). The assessment considered the status of each DPS individually, as well as all five DPSs collectively as a single unit. The assessment determined the South Atlantic DPS abundance is "depleted" relative to historical levels. The assessment concluded there was not enough information available to assess the abundance of the DPS since the implementation of the 1998 fishing moratorium. However, it did conclude there was 40% probability the South Atlantic DPS is still subjected to mortality levels higher than determined acceptable in the 2017 assessment. The assessment also estimated effective population sizes (N_e) when possible. Effective population size is generally considered to be the number of individuals that contribute offspring to the next generation. More specifically, based on genetic differences between animals in a given year, or over a given period of time, researchers can estimate the number of adults needed to produce that level of genetic diversity. For the South Atlantic DPS, the assessment reported N_e for the Edisto, Savannah, Ogeechee, and Altamaha rivers (Table 47). Additional estimates of N_e have been conducted since the completion of the assessment, including for additional river systems; Table 48 reports those estimates. White et al. (2021b) cautions that, because the populations they considered were sampled at varying temporal scales and intensities and represented a mixture of single and mixed-cohort samples, the N_e estimates they report should be interpreted with reservation as they technically represent a value between true N_e and the effective number of breeders. They also state that, while their estimates are valuable for comparing the general magnitude of difference among populations, they should not be used to make inferences about long-term population viability (White et al. 2021b).

Table 47. Available Estimates of Effective Population Sizes in the Rivers of the South Atlantic DPS

River	Effective Population Size (N _e) (95% CI)	Sample Size	Collection Years	Reference
Edisto	55.4 (36.8-90.6)	109	1996-2005	ASMFC (2017)
	Fall Run – 48.0 (44.7-51.5)	1,154	1996-2004	Farrae et al. (2017)
	Fall Run (82 (60.3-122.1)	373	1996, 1998, 2001-2003, 2005	White et al. (2021b)
	Spring Run – 13.3 (12.1-14.6)	198	1998, 2003	Farrae et al. (2017)
	Spring Run – 16.4 (12.8-20.6)	123	1998, 2003	White et al. (2021b)
	60.0 (51.9-69.0)	145	1996, 1998, 2005	Waldman et al. (2019)
	126.5 (88.1-205)	98	2000-2013	ASMFC (2017)
Savannah	123 (103.1-149.4)	161	2013, 2014, 2017	Waldman et al. (2019)
	154.5 (99.6-287.7)	134	2000, 2007, 2208, 2013, 2017, 2018	White et al. (2021b)
	32.2 (26.9-38.8)	115	2003-2015	ASMFC (2017)
	26 23.9–28.2	200	2007-2009, 2014-2017	Waldman et al. (2019)
Ogeechee	23.9 (22.2-25.7)	197	2007-2009, 2014-2017	Fox et al. (2019)
	Spring Run – 31.1 (24.3-40.2)	92	2003, 2007, 2009, 2014, 2015, 2016	White et al. (2021b)
	Fall Run – 56.5 (36.3-103.6)	55	2003, 2004, 2008, 2009, 2015, 2016	White et al. (2021b)
	111.9 (67.5-216.3)	186	2005-2015	ASMFC (2017)

River	Effective Population Size (N_e) (95% CI)	Sample Size	Collection Years	Reference
Altamaha	149 (128.7–174.3)	245	2005, 2011, 2014, 2016-2017	Waldman et al. (2019)
	142.1 (124.2-164.0)	268	2005, 2011, 2014-2017	Fox et al. (2019)
	141.7 (73.4-399)	189	2005, 2010, 2011, 2018	White et al. (2021b)
Satilla	21 (18.7–23.2)	68	2015-2016	Waldman et al. (2019)
	11.4 (9.1-13.9)	74	2010, 2014, 2016	White et al. (2021b)
St. Marys	1 (1.3–2.0)	14	2014-2015	Waldman et al. (2019)

Generally, a minimum N_e of 100 individuals is considered the threshold required to limit the loss in total fitness from in-breeding depression to <10%; while an N_e greater than 1,000 is the recommended minimum to maintain evolutionary potential (Frankham et al. 2014; ASMFC 2017). Effective population size is useful for defining abundance levels where populations are at risk of loss of genetic fitness (ASMFC 2017). While not inclusive of all the spawning rivers in the South Atlantic DPS, the population estimates reported in Table 47 suggest there is a risk for inbreeding depression ($N_e < 100$) in four of those rivers (Edisto, Ogeechee, Satilla, and St. Marys rivers) and loss of evolutionary potential ($N_e < 1000$) in all six. This information suggests there at least some inbreeding depression within the DPS and loss of evolutionary potential throughout all of it. However, White et al. (2021b), stated that while historic comparisons are currently not available, all 18 populations surveyed showed reasonably high levels of contemporary genetic diversity and low inbreeding despite relatively recent and severe demographic bottleneck events.

A census estimate was produced for the upper 20 km of the Savannah River (river kilometers 281-301) to estimate the number of purported spawning adults in that stretch on a given day over 50 sampling occasions. The maximum estimate of daily abundance in those 20 km was 35 to 55 adults of unknown sex (Vine et al. 2019). Effective population estimates were also produced for many rivers in the South Atlantic DPS. The Edisto River ($n = 145$) was estimated to have an effective population of 60 (95% CL, 51.9-69.0; (Waldman et al. 2019), but was broken into two spawning populations by (White et al. 2021b) following the identification of two distinct spawning groups (Farrae et al. 2017) for estimates of a spring run ($n = 123$) of 16.4 (12.8-20.6) and a fall run ($n = 373$) of 47.9 (25.3-88.8). The Savannah River was estimated to have an effective population size ($n = 161$) of approximately 123 (103.1-149.4) and also ($n = 134$) of approximately 154.5 (99.6-287.7) by White et al. (2021b) and Waldman et al. (2019), respectively. The Ogeechee River ($n = 200$) was estimated to have an effective population of 26 (23.9-28.2; Waldman et al. 2019), but was also broken into two spawning populations by White

et al. (2021b) for estimates of a spring run ($n = 92$) of 31.1 (24.3-40.2) and a fall run ($n = 55$) of 56.5 (36.3-103.6). The Altamaha River appears to support the largest Atlantic sturgeon population in the South Atlantic DPS, and one of the largest on the East Coast, with effective population estimates of 149 (128.7-174.3; $n = 245$; (Waldman et al. 2019) and 141.7 (73.4-399; $n = 189$; (White et al. 2021b). The effective population estimates for the Satilla River population are 21 (18.7-23.2; $n = 68$; Waldman et al. 2019) and 11.4 (9.1-13.9; $n = 74$; White et al. 2021a). Work in the St. Marys River on the Florida-Georgia border captured 25 fish including 14 river resident juveniles. Analysis of those individuals reveals an effective population size of 1 (1.3-2.0), but this is a known under-estimate because those individuals were from a single spawning event (Fox et al. 2018; Waldman et al. 2019). The St. Johns River in Florida does not appear to support an extant population (Fox et al. 2018). Survival within the entire DPS was estimated to be approximately 86% (54-99%; (ASMFC 2017).

The relatedness of the populations reveals three groups of related clusters within this DPS. The first cluster includes the Edisto spring run, the Ogeechee Spring run, and the Satilla River populations; the second includes the Edisto River fall run and Ogeechee River fall run; and the third includes the largest populations of the Savannah and Altamaha Rivers, but also the Ogeechee River fall run (White et al. 2021b). As was seen with other rivers with dual spawning populations, the spring and fall runs are genetically differentiated.

Kazyak et al. (2021) presented the first comprehensive mixed stock analysis of Atlantic sturgeon in the Southeast and confirmed that while Atlantic sturgeon are making long-distance migrations, stock composition is best assessed at a regional level. The mixed stock analysis identified relatively little mixing of stocks in the Southeast. Of the 513 samples assigned to the “South” region (Cape Hatteras, NC to FL) the most common DPS was South Atlantic (91.2%, $n=468$) followed by Carolina DPS (6.2%; $n=32$), with only 2.6% ($n=13$) of the samples originating from other DPSs (Kazyak et al. 2021).

South of Cape Hatteras, Kazyak et al. (2021) showed that 91.2% of fisheries bycatch was from the South Atlantic DPS. In terms of population level distribution and susceptibility to commercial fisheries, 35.7% were from the Altamaha River, 21.4% from the Edisto River fall-run, 18.9% from the Savannah River, 7.2% from the Ogeechee River (both spring and fall), 5.5% Satilla, 3.7% Pee Dee (both spring and fall), and 2.0% Edisto spring-run. In the south, most offshore fish were from the Altamaha, followed by the Savannah (Kazyak et al. 2021). Within river movement studies also revealed that age-1 fish that were tagged in the summer remained in the rivers and overwintered before out-migrating between December and March (Fox and Peterson 2019). When observing the likelihood of becoming a coastally wandering sub-adult or remaining a river resident for another year, Fox and Peterson (2019) found that 36.7% returned as age 2 fish while 30.4% out-migrated as age 2. The St. Johns River, the furthest south in the South Atlantic DPS, has periodic use by sub-adults and adults, but is no longer spawning or rearing habitat.

The viability of the South Atlantic DPS depends on having multiple self-sustaining riverine spawning populations and maintaining suitable habitat to support the various life functions (spawning, feeding, and growth) of Atlantic sturgeon populations. Because a DPS is a group of

populations, the stability, viability, and persistence of individual populations affects the persistence and viability of the larger DPS. The loss of any population within a DPS will result in (1) a long-term gap in the range of the DPS that is unlikely to be recolonized, (2) loss of reproducing individuals, (3) loss of genetic biodiversity, (4) potential loss of unique haplotypes, (5) potential loss of adaptive traits, (6) reduction in total number, and (7) potential for loss of population source of recruits. The loss of a population will negatively impact the persistence and viability of the DPS as a whole, as fewer than two individuals per generation spawn outside their natal rivers (Wirgin et al. 2000; King et al. 2001; Waldman et al. 2002). The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, the immigration into marine habitats to grow, and then the return of adults to natal rivers to spawn.

4.2.14 Giant Manta Ray

The giant manta ray (previously *Manta birostris*) was listed as threatened under the ESA on January 22, 2018 (83 FR 2916) because the species is likely to become an endangered species within the foreseeable future throughout a significant portion of its range (the Indo-Pacific and eastern Pacific portion). On November 22, 2023, the listing was revised to reflect the giant manta ray's updated taxonomy (*Mobula birostris*; 88 FR 81351).

The giant manta ray is found worldwide in tropical and subtropical oceans and in productive coastal areas. They also occasionally occur within estuaries (e.g., lagoons and bays) and Intracoastal Waterways. In terms of range, within the Northern hemisphere, the species has been documented as far north as southern California and New Jersey on the United States west and east coasts, respectively, and Mutsu Bay, Aomori, Japan, the Sinai Peninsula and Arabian Sea, Egypt, and the Azores Islands (Gudger 1922; Kashiwagi et al. 2010; Moore 2012; CITES 2013). In the Southern Hemisphere, the species occurs as far south as Peru, Uruguay, South Africa, New Zealand and French Polynesia (Mourier 2012; CITES 2013). Within its range, the giant manta ray inhabits tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines (Figure 36) (Marshall et al. 2009; Kashiwagi et al. 2011).



Figure 36. Extent of Occurrence (dark blue) and Area of Occupancy (light blue) for Giant Manta Rays based on Species Distribution (Lawson et al. 2017)

Life History

Giant manta rays make seasonal long-distance migrations, aggregate in certain areas and remain resident, or aggregate seasonally (Dewar et al. 2008; Graham et al. 2012; Girondot et al. 2015; Stewart et al. 2016). The giant manta ray is a seasonal visitor along productive coastlines with regular up-welling, in oceanic island groups, and at offshore pinnacles and seamounts. The timing of these visits varies by region and seems to correspond with the movement of zooplankton, current circulation and tidal patterns, seasonal up-welling, seawater temperature, and possibly mating behavior. They have also been observed in estuarine waters inlets, with use of these waters as potential nursery grounds (Adams and Amesbury 1998; Milessi and Oddone 2003; Medeiros et al. 2015).

Giant manta rays are known to aggregate in various locations around the world in groups usually ranging from 100 to 1,000 (Notarbartolo-di-Sciara and Hillyer 1989; Graham et al. 2012; Venables 2013). These sites function as feeding sites, cleaning stations (areas where smaller fish and crustaceans eat parasites off giant manta rays), or sites where courtship interactions take place (Heinrichs et al. 2011; Graham et al. 2012; Venables 2013). The appearance of giant manta rays in these locations is generally predictable. For example, food availability due to high productivity events tends to play a significant role in feeding site aggregations (Notarbartolo-di-Sciara and Hillyer 1989; Heinrichs et al. 2011). Giant manta rays have also been shown to return to a preferred site of feeding or cleaning over extended periods of time (Dewar et al. 2008; Graham et al. 2012; Medeiros et al. 2015). In addition, giant and reef manta rays in Keauhou and Ho'ona Bays in Hawaii appear to exhibit learned behavior. These manta rays learned to associate artificially lighting with high plankton concentration (primary food source) and shifted foraging strategies to include sites that had artificially lighting at night (Clark 2010). While little is known about giant manta ray aggregation sites, the Flower Garden Banks National Marine Sanctuary and the surrounding region might represent the first documented nursery habitat for giant manta ray (Stewart et al. 2018b). Stewart et al. (2018b) found that the Flower Garden Banks National Marine Sanctuary provides nursery habitat for juvenile giant manta rays because small age classes have been observed consistently across years at both the population and individual level. The Flower Garden Banks National Marine Sanctuary may be an optimal nursery ground because of its location near the edge of the continental shelf and proximity to abundant pelagic food resources. In addition, small juveniles are frequently observed along a portion of Florida's east coast, indicating that this area may also function as a nursery ground for juvenile giant manta rays. Since directed visual surveys began in 2016, juvenile giant manta rays are regularly observed in the shallow waters (less than 5 m depth) from Jupiter Inlet to Boynton Beach Inlet (J Pate, Florida Manta Project, unpublished data). However, the extent of this purported nursery ground is unknown as the survey area is limited to a relatively narrow geographic area along Florida's southeast coast.

The giant manta ray appears to exhibit a high degree of plasticity in terms of its use of depths within its habitat. Tagging studies have shown that the giant manta rays conduct night descents from 200 to 450 m depths (Rubin et al. 2008; Stewart et al. 2016) and are capable of diving to depths exceeding 1,000 m (A. Marshall et al. unpublished data 2011, cited in Marshall et al.

(2011)). Stewart et al. (2016) found diving behavior may be influenced by season, and more specifically, shifts in prey location associated with the thermocline, with tagged giant manta rays (n=4) observed spending a greater proportion of time at the surface from April to June and in deeper waters from August to September. Overall, studies indicate that giant manta rays have a more complex depth profile of their foraging habitat than previously thought, and may actually be supplementing their diet with the observed opportunistic feeding in near-surface waters (Couturier et al. 2013; Burgess et al. 2016).

Giant manta rays primarily feed on planktonic organisms such as euphausiids, copepods, mysids, decapod larvae and shrimp, but some studies have noted their consumption of small and moderately sized fishes (Miller 2017). While it was previously assumed, based on field observations, that giant manta rays feed predominantly during the day on surface zooplankton, results from recent studies (Couturier et al. 2013; Burgess et al. 2016) indicate that these feeding events are not an important source of the dietary intake. When feeding, giant manta rays hold their cephalic lobes in an “O” shape and open their mouth wide, which creates a funnel that pushes water and prey through their mouth and over their gill rakers. They use many different types of feeding strategies, such as barrel rolling (doing somersaults repeatedly) and creating feeding chains with other mantas to maximize prey intake.

The giant manta ray is viviparous (i.e., gives birth to live young). They are slow to mature and have very low fecundity and typically give birth to only one pup every two to three years. Gestation lasts approximately 10 to 14 months. Females are only able to produce between five and 15 pups in a lifetime (CITES 2013; Miller 2017). The giant manta ray has one of the lowest maximum population growth rates of all elasmobranchs (Dulvy et al. 2014; Miller 2017). The giant manta rays generation time (based on *M. alfredi* life history parameters) is estimated to be 25 years (Miller 2017).

Although giant manta rays have been reported to live at least 40 years, not much is known about their growth and development. Maturity is thought to occur between eight to ten years of age (Miller 2017). Males are estimated to mature at around 3.8 m disc width (slightly smaller than females) and females at 4.5 m disc width (Rambahiniarison et al. 2018).

Population Dynamics

There are no current or historical estimates of global abundance of giant manta rays, with most estimates of subpopulations based on anecdotal observations. Subpopulation abundance estimates range between 42 and 1,500 individuals, but are anecdotal and subject to bias (Miller 2017). There is no available information on population trend for the species.

There is very little information on the abundance or spatial structure of the species within the Atlantic portion of its range (Miller 2017). The population near St. Augustine, Florida, is estimated at between 90 and less than 500 individuals (Kendall 2010); this population is the closest to the action area for which we have information. In the U.S. Atlantic and Caribbean, giant manta ray sightings are concentrated along the east coast as far north as New Jersey, within the Gulf of America, and off the coasts of the U.S. Virgin Islands and Puerto Rico. Because most sightings of the species have been opportunistic during other surveys, researchers are still unsure

what attracts giant manta rays to certain areas and not others and where they go for the remainder of the time (NMFS 2019b).

The available sightings data indicate that giant manta rays occur regularly along Florida's east coast. In 2010, Georgia Aquarium began conducting aerial surveys for giant manta rays. The surveys are conducted in spring and summer and run from the beach parallel to the shoreline (zero to 2.5 NM), from St. Augustine Beach Pier to Flagler Beach Pier, Florida, north of the action area. The numbers, location, and peak timing of the manta rays to this area varies by year (H. Webb unpublished data). In addition, juvenile giant manta rays have also been regularly observed inshore off the southeast Florida, approximately 95 miles (154 km) south of the action area. Since 2016, researchers with the Marine Megafauna Foundation have been conducting annual surveys along a small transect off Palm Beach, Florida, between Jupiter Inlet and Boynton Beach Inlet (about 44 km [24 NM]) (J. Pate, MMF, pers. comm. to M. Miller, NMFS OPR, 2018). Results from these surveys indicate that juvenile manta rays are present in these waters for the majority of the year (observations span from May to December), with re-sightings data that suggest some manta rays may remain in the area for extended periods of time or return in subsequent years (J. Pate unpublished data). In the Gulf of America, within the Flower Garden Banks National Marine Sanctuary, 95 unique individuals have been recorded between 1982 and 2017 (Stewart et al. 2016).

Clark (2010) suggests that giant manta rays may forage in less productive pelagic waters and conduct seasonal migrations following prey abundance. Satellite tracking studies using pop-up satellite archival tags registered movements of the giant manta ray from the Yucatan, Mexico, into the Gulf of America (448 km) (Marshall et al. 2016). Despite this large range, sightings are often sporadic. The timing of these sightings also varies by region (for example, the majority of sightings in Brazil occur during June and September, while in New Zealand sightings mostly occur between January and March) and seems to correspond with the movement of zooplankton, current circulation and tidal patterns, seawater temperature, and possibly mating behavior (De Boer et al. 2015; Armstrong et al. 2016). However, a study by Stewart et al. (2016) suggests that the species may not be as highly migratory as previously thought. Using pop-up satellite archival tags in combination with analyses of stable isotope and genetic data, the authors found evidence that giant manta rays may actually exist as well structured subpopulations off Mexico's coast that exhibit a high degree of residency (Stewart et al. 2016). Within its range, the giant manta ray inhabits tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines (Marshall et al. 2009; Kashiwagi et al. 2011). As such, giant manta rays can be found in cooler water, as low as 19° Celsius, although temperature preference appears to vary by region (Duffy and Abbott 2003; Marshall et al. 2009; Freedman and Roy 2012; Graham et al. 2012).

Farmer et al. (2022a) utilized sightings and survey effort data from numerous sources and decades of sampling across a broad geographic range to create a species distribution model of giant manta ray occurrence. The most sightings and largest groups reported in the Gulf of America were near the mouth of the Mississippi River, in the Atlantic off the east coast of Florida. Per the model, peak manta ray use in the Gulf of America is concentrated near the

Mississippi River delta during the spring (April to June) and fall (October to November), but more dispersed and farther from shore during the remainder of the year.

Vocalization and Hearing

Giant manta rays are elasmobranchs, and although there is no known information on their sound production and hearing abilities, these abilities have been studied in other elasmobranchs species. Elasmobranchs, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001). Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Myrberg 2001; Casper et al. 2003; Casper 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013).

Status

Although manta rays have been reported to live for at least 40 years (Marshall and Bennett 2010; Kitchen-Wheeler 2013; Marshall et al. 2016) with low rates of natural mortality, the time needed to grow to maturity and the low reproductive rates mean that a female will be able to produce only five to fifteen pups in her lifetime. In the Atlantic, very little information on giant manta ray populations is available, but there is a known, protected population within the Flower Garden Banks National Marine Sanctuary in the Gulf of America. However, researchers are still trying to determine whether the manta rays in this area are only giant manta ray individuals or potentially also comprise individuals of a new, undescribed species (Marshall et al. 2009; Hinojosa-Alvarez et al. 2016). The best available data indicate that the giant manta ray has suffered population declines (up to 95%, in some areas), based on landings and market data, diver observations, and anecdotal sightings. The declines are largely believed to be caused by overfishing (Miller 2017). In areas where the species is not subject to fishing, populations may be stable. For example, Rohner et al. (2013) reported that giant manta ray sightings remained constant off the coast of Mozambique over a period of eight years. Given the migratory nature of this species, population declines in waters where the manta rays are protected have also been observed but attributed to overfishing of the species in adjacent areas within its large home range. With populations potentially ranging from around 100 to 1,500 individuals (see Table 4 in Miller (2017)), their life history traits and productivity estimates, particularly their low reproductive output and sensitivity to changes in adult survival rates, giant manta ray populations are inherently vulnerable to depletions, with low likelihood of recovery.

Critical Habitat

NMFS determined that the designation of critical habitat for giant manta ray was not determinable because data sufficient to perform the required analyses were lacking (NMFS 2019b).

Recovery Goals

On December 19, 2019, NMFS published a recovery outline, which serves as an interim guidance to direct recovery efforts for giant manta ray (NMFS 2019d). The initial focus of the interim recovery program is two-fold: 1) to stabilize population trends through reduction of threats, such that the species is no longer declining throughout a significant portion of its range; and 2) to gather additional information through research and monitoring on the species' current distribution and abundance, movement and habitat use of adult and juveniles, mortality rates in commercial fisheries (including at-vessel and post-release mortality), and other potential threats that may contribute to the species' decline.

Because the major threat currently contributing to the species' decline is overutilization in waters outside of U.S. jurisdiction, international coordination will be critical to ensuring recovery of the species. Therefore, to be effective, these actions would need to be undertaken throughout the species' range, both domestically and internationally.

4.2.15 Gulf Sturgeon

The Gulf sturgeon was listed as threatened on September 30, 1991 (56 FR 49653). NMFS and the U.S. Fish and Wildlife Service jointly manage Gulf sturgeon under the ESA. NMFS is responsible for consultations on actions affecting Gulf sturgeon and their critical habitat in marine habitats. The U.S. Fish and Wildlife Service is responsible for Gulf sturgeon consultations in riverine habitats. In estuarine habitats, responsibility is divided based on the action agency involved: the U.S. Fish and Wildlife Service consults with the Department of Transportation, the U.S. Environmental Protection Agency, the U.S. Coast Guard, and the Federal Emergency Management Agency; NMFS consults with the Department of Defense, USACE, the Bureau of Ocean Energy Management, and any other Federal agencies not specifically mentioned at 50 CFR 226.214. In 2009, NMFS and the U.S. Fish and Wildlife Service conducted a 5-year review and found Gulf sturgeon continued to meet the definition of a threatened species (USFWS and NMFS 2009).

The current range of the Gulf sturgeon extends from Lake Pontchartrain in Louisiana east to the Suwannee river system in Florida (Figure 37). Within that range, seven major rivers are known to support reproducing populations: Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicola, and Suwannee.

Gulf sturgeon are benthic fusiform fish with an extended snout, vertical mouth, five rows of scutes (bony plates surrounding the body), four barbels (slender, whisker-like feelers anterior to the mouth used for touch and taste), and a heterocercal (upper lobe is longer than lower) caudal fin. Adults range from 6 to 8 ft in length and weigh up to 200 lbs; females grow larger than males (USFWS and NMFS 2009).

We used information available in the 2009 and 2022 5-year status reviews (USFWS and NMFS 2009; USFWS and NMFS 2022) and the scientific literature summarize the life history, population dynamics, and status of the species, as follows.

Life history

Gulf sturgeon are long-lived, with some individuals reaching at least 42 years in age. Surveys in the Suwannee River suggest that a more common maximum age may be around 25 years (Sulak and Clugston 1999). Age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years (Huff 1975). In general, Gulf sturgeon spawn up-river in spring, spend winter months in near-shore marine environments, and utilize pre- and post-spawn staging and nursery areas in the lower rivers and estuaries (Heise et al. 2004; Heise et al. 2005). There is some evidence of autumn spawning in the Suwannee River, however there is uncertainty as to whether this spawning is due to environmental conditions or represents a genetically distinct population (Randall and Sulak 2012). Zona et al. (2025) found genetic evidence of a fall spawning group of Gulf sturgeon in the Apalachicola River, Florida.

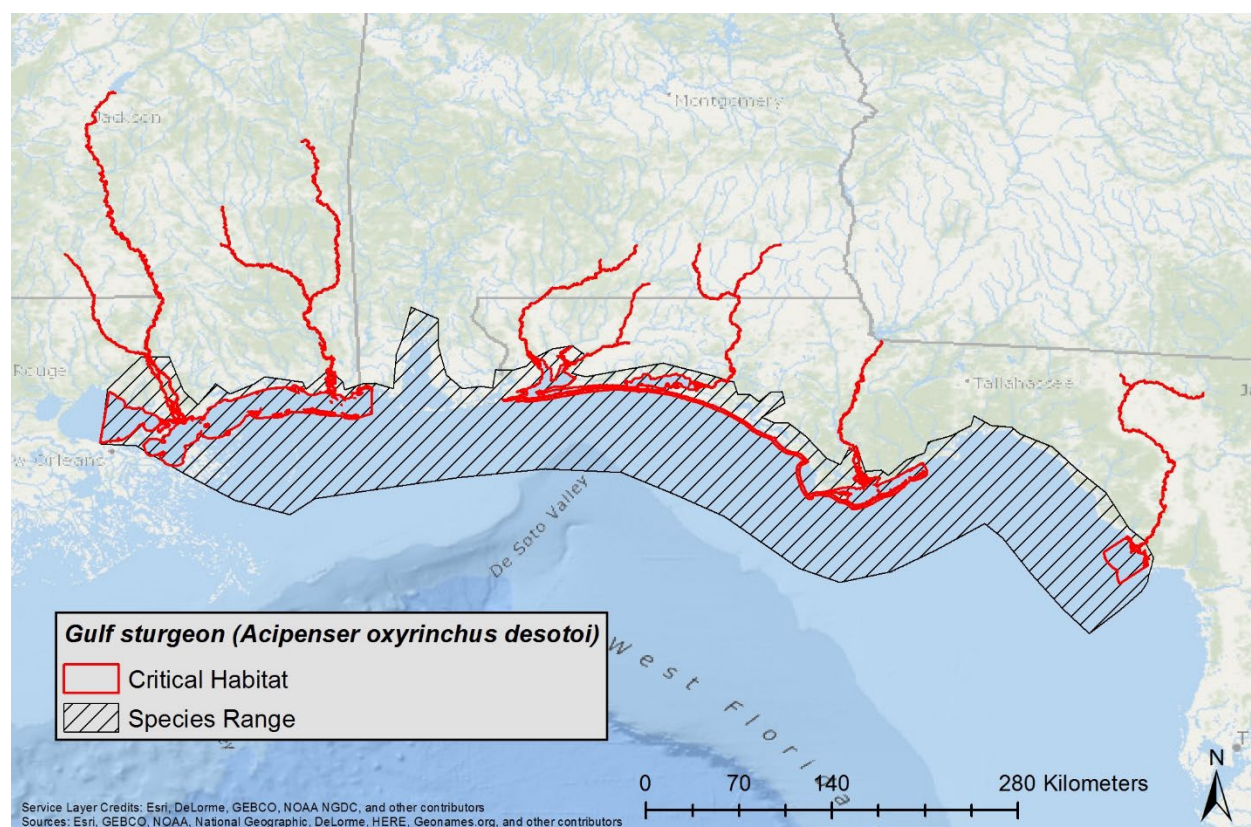


Figure 37. Geographic Range and Designated Critical Habitat of the Gulf Sturgeon

Gulf sturgeon spawn at intervals ranging from 3 to 5 years for females and 1 to 5 years for males (Smith 1985; Fox et al. 2000). The spring migration to up-river spawning sites begins in mid-February and continues through May. Fertilization is external; females deposit their eggs in the upper reaches of and show preference for hard, clean substrate (e.g., bedrock covered in gravel and small cobble).

Upon hatching from their eggs, Gulf sturgeon larvae spend the first few days of life sheltered in interstitial spaces at the spawning site (Kynard and Parker 2004). At the onset of feeding, age-0 Gulf sturgeon disperse and are often found on shallow sandbars and rippled sand shoals (less

than 4 m depth) (Sulak and Clugston 1998). Young-of-the-year spend 6 to 10 months slowing working their way downstream feeding on aquatic insects (e.g., mayflies and caddisflies), worms (oligochaetes), and bivalve mollusks, and arrive in estuaries and river mouths by mid-winter (Sulak and Clugston 1999) where they will spend their next 6 years developing. After spawning, adult Gulf sturgeon migrate downstream to summer resting and holding areas in the mid to lower reaches of the rivers where they may hold until November (Wooley and Crateau 1985). While in freshwater adults lose a substantial amount of their weight, but regain it upon entering the estuaries. Sub adult and non-spawning adults also spend late spring through fall in these holding areas (Foster and Clugston 1997). By early December all adult and sub-adult Gulf sturgeon return to the marine environment to forage on benthic (bottom-dwelling) invertebrates along the shallow nearshore (2 to 4 m depth), barrier island passes, and in unknown off-shore locations in the gulf (Huff 1975; Carr et al. 1996; Fox et al. 2002; Ross et al. 2009). Juvenile Gulf sturgeon overwinter in estuaries, river mouths, and bays; juveniles do not enter the nearshore/offshore marine environments until around age 6 (Sulak and Clugston 1999). Gulf sturgeon show a high degree of river-specific fidelity (Rudd et al. 2014). Adult and sub-adult Gulf sturgeon fast while in freshwater environments and are almost entirely dependent on the estuarine/marine environment for food (Wooley and Crateau 1985; Gu et al. 2001). Some juveniles (ages 1 to 6) will also fast in the freshwater summer holding areas, but the majority feed year round in the estuaries, river mouths, and bays (Sulak et al. 2009).

Population Dynamics

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

Currently, seven rivers are known to support reproducing populations of Gulf Sturgeon; these same seven populations existed at the time the species was listed. Several populations were extirpated prior to listing; of these, the Mobile River basin likely had the largest reproducing population (Sulak et al. 2016). The most recent abundance estimates were reported in the 5-Year Status Review conducted in 2022 (USFWS and NMFS 2022). The largest estimated populations of Gulf sturgeon are found in the Suwannee (14,000), the Choctawhatchee (3,314), and the Yellow (911) rivers. The most recent population estimates for the other four rivers with known reproducing populations are all below 500.

Gulf sturgeon abundance trends are typically assessed on a riverine basis. In general, Gulf sturgeon populations in the eastern portion of the range appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty (USFWS and NMFS 2022). Pine and Martell (2009) reported that, due to low recapture rates and sparse data, the population viability of Gulf sturgeon is currently uncertain.

When grouped by genetic relatedness, five regional or river-specific stocks emerge: (1) Lake Pontchartrain and Pearl River; (2) Pascagoula River; (3) Escambia, Blackwater and Yellow Rivers; (4) Choctawhatchee River; and (5) Apalachicola, Ochlocknee and Suwannee Rivers

(Stabile et al. 1996; Rudd et al. 2014). Gene flow is low in Gulf sturgeon stocks, with each stock exchanging less than one mature female per generation (Waldman and Wirgin 1998).

When Gulf sturgeon are in nearshore waters of the Gulf of America, they occur primarily from shore out to approximately 1.4 nautical miles (2.6 km) offshore (Fox et al. 2002; Ross et al. 2009). Given the commonly cited detection range of 500 m, some individuals could have been at least 1.75 km from shore.

Gulf Sturgeon population growth is likely driven by adult survival, not recruitment to the adult life stage (Parker et al. 2025). While rangewide population growth rate suggests stable or slightly increasing adult populations, river-level trends vary (Parker et al. 2025). Recent declines in both population growth rate and recruitment have been observed in the Escambia, Apalachicola, and Suwannee - rivers systems affected by red tide, hurricanes, or oil exposure following the Deepwater Horizon spill (Parker et al. 2025).

Vocalization and Hearing

Sturgeon are known to produce sounds, especially during spawning. Lake sturgeon produce low frequency sounds during spawning bouts, principally consisting of drumming sounds that range from 5 to 8 Hz, but low frequency rumbles and hydrodynamic sounds as well as high frequency sounds have also been reported (Bocast et al. 2014). The pallid sturgeon (*Scaphirhynchus albus*) and shovelnose sturgeon (*Scaphirhynchus platyrhynchus*) are known to produce at least four types of sounds during the breeding season, ranging from squeaks and chirps from 1 to 2 kHz, with low frequency moans ranging in frequency between 90 and 400 Hz (Johnston and Phillips 2003). Based on these related sturgeon species, we assume Gulf sturgeon are capable of producing both low and high frequency sounds, mostly likely during the breeding season.

While sturgeon have swim bladders, they are not known to be used for hearing, and thus sturgeon appear to only rely directly on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz, indicating that sturgeon should be able to localize or determine the direction of origin of sound. Meyer and Popper (2002) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for Oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon were more similar to goldfish (which is considered a hearing specialist that can hear up to five kHz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing (Meyer and Popper 2002). Lovell et al. (2005) also studied sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300

Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of Gulf sturgeon.

Status

The decline in the abundance of Gulf sturgeon has been attributed to targeted fisheries in the late 19th and early 20th centuries, habitat loss associated with dams and sills, habitat degradation associated with dredging, de-snagging, and contamination by pesticides, heavy metals, and other industrial contaminants, and certain life history characteristics (e.g., slow growth and late maturation). Effects of changing environmental conditions (warmer water, sea level rise and higher salinity levels) could lead to accelerated changes in habitats utilized by Gulf sturgeon. The rate that environmental conditions are changing and corollary impacts are occurring may outpace the ability of the Gulf sturgeon to adapt given its limited geographic distribution and low dispersal rate. In general, Gulf sturgeon populations in the eastern portion of the range appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty (USFWS and NMFS 2009). Long-term recovery of Gulf Sturgeon is likely more sensitive to adult survival than recruitment to the adult population (Parker et al. 2025).

Critical Habitat

See Section 4.1.3 Atlantic Sturgeon Designated Critical Habitat above.

Recovery Goals

The 1995 Recovery Plan outlined three recovery objectives: (1) to prevent further reduction of existing wild populations of Gulf sturgeon within the range of the subspecies; (2) to establish population levels that would allow delisting of the Gulf sturgeon by management units (management units could be delisted by 2023 if required criteria are met); (3) to establish, following delisting, a self-sustaining population that could withstand directed fishing pressure within management units (USFWS and GSMFC 1995).

4.2.16 Oceanic Whitetip Shark

On January 30, 2018, NMFS listed the oceanic whitetip shark (*Carcharhinus longimanus*) as a threatened species throughout its range (83 FR 4153). The oceanic whitetip shark is globally distributed in epipelagic tropical and subtropical waters (Figure 38) between 30° North and 35° South latitudes (Rigby *et al.* 2019; Young and Carlson 2020).



Figure 38. Geographic Range of the Oceanic Whitetip Shark

The oceanic whitetip shark was characterized historically as one of the most abundant oceanic sharks (Mather and Day 1954; Backus *et al.* 1956; Compagno 1984); it is usually found offshore in the open ocean, on the outer continental shelf, or around oceanic islands in deep water greater than 184 m, and occurs from the surface to at least 152 m depth. This species has a clear preference for open ocean waters between 10°N and 10°S, but can be found in decreasing numbers out to latitudes of 30°N and 35°S, with abundance decreasing with greater proximity to continental shelves (Backus *et al.* 1956; Strasburg 1958; Compagno 1984; Bonfil *et al.* 2008). Oceanic whitetip sharks have very long and wide paddle-shaped pectoral fins with characteristic mottled white tips (also present on the front dorsal and caudal fins). Its body is grayish bronze to brown, and white underneath. Adults can grow up to 3.4 m and 230 kilograms.

We used information available in the 2024 Status Review (NMFS 2024d), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

Life History

The oceanic whitetip shark gives birth to live young (i.e., “viviparous”). Their reproductive cycle is thought to be biennial, giving birth on alternate years, after a lengthy 10 to 12-month gestation period. The number of pups in a litter ranges from one to 14 (mean = 6), and a positive correlation between female size and number of pups per litter has been observed, with larger sharks producing more offspring (Compagno 1984; Seki *et al.* 1998; Bonfil *et al.* 2008; IOTC 2014). Not a great deal is known about oceanic whitetip sharks’ lifespan. Estimates range from 12 to 13 years (Seki *et al.* 1998; Lessa *et al.* 1999), to 17 years, and even up to 20 years old (Young *et al.* 2017). They are a slow-growing species, and growth rates are believed to be similar between the sexes (Seki *et al.* 1998; Lessa *et al.* 1999; Joung *et al.* 2016; Young *et al.* 2017). Age at maturity varies by ocean region, with six to seven years old recorded in the southwest Atlantic, and four to nine years old in the North Pacific, with the sexes having similar ages at maturity (Seki *et al.* 1998; Lessa *et al.* 1999; Joung *et al.* 2016).

Little is known about the movement or possible migration paths of the oceanic whitetip shark. Oceanic whitetip sharks are highly migratory, and satellite telemetry data of seven sharks tagged in French Polynesia revealed movement across net distances of 1,625 to 7,885 km (Burkhardt et al. 2025). Although the species is considered highly migratory and capable of making long distance movements, tagging data provides evidence that this species also exhibits a high degree of philopatry (i.e., site fidelity) in some locations (Gao et al. 2024). In the Atlantic, young oceanic whitetip sharks have been found well offshore along the southeastern coast of the U.S., suggesting that there may be a nursery in oceanic waters over this continental shelf (Compagno 1984; Bonfil et al. 2008). In the southwestern Atlantic, the prevalence of immature sharks, both female and male, in fisheries catch data suggests that this area may serve as potential nursery habitat for the oceanic whitetip shark (Coelho et al. 2009; Tambourgi et al. 2013; Frédou et al. 2015; Tolotti et al. 2015). Juveniles seem to be concentrated in equatorial latitudes, while specimens in other maturational stages are more widespread (Tambourgi et al. 2013). Pregnant females are often found close to shore, particularly around the Caribbean Islands.

There is no information regarding established foraging grounds for the oceanic whitetip shark. Recent tracking studies from the Bahamas, Brazil, and the Indian Ocean have revealed complex vertical movements in the species and diel behavior changes (Papastamatiou *et al.* 2018; Tolotti *et al.* 2017; Howey *et al.* 2016). Based on tracking data from the Bahamas, oceanic whitetip sharks regularly exhibit mesopelagic excursions (defined as ≥ 5 consecutive depth records below 200 m), particularly during dusk periods that may be related to foraging (Howey *et al.* 2016). Tolotti *et al.* (2017) noted that deep dives below 150 m were rare, but the variation seen in the shark's vertical movement patterns could be linked to prey distribution as well. Papastamatiou *et al.* (2018) further reaffirms this possibility with evidence from oceanic whitetip sharks outfitted with cameras. Potential prey (mackerel, scad, and squid) were observed during dives (as opposed to when individuals were in shallow water) and at the apex of the dive when bursts of speed were common (Papastamatiou *et al.* 2018). Andrzejczek et al. (2018) modeled the effects of sea surface temperature on oceanic whitetip shark movements and found they generally oscillated throughout the upper 200 meters (656 feet) of the water column. However, in summer they reduced the amount of time spent in the upper 50 meters (164 feet), and in winter oscillations decreased in amplitude and cycle length and sharks frequently occupied the upper 50 meters. Recently, an oceanic whitetip shark was observed off the coast of Kona, Hawaii, with scars caused by the tentacles of a large cephalopod. This suggests oceanic whitetip sharks dive within the mesopelagic zone and may interact with or even forage for large cephalopods (Papastamatiou *et al.* 2020).

Oceanic whitetip sharks are regarded as opportunistic feeders, eating teleosts (bony fishes) and cephalopods. Large pelagic fish species commonly found in the stomachs of oceanic whitetips include, blackfin tuna, white marlin, and barracuda.

Population Dynamics

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

Historically, the oceanic whitetip shark was described as widespread, abundant, and the most common pelagic shark in the warm parts of the North Atlantic (Young and Carlson 2020). Historical accounts of the oceanic whitetip shark during exploratory research surveys in the western North Atlantic during the 1950s noted that several individuals (up to 25 individuals in some cases) often gathered at the surface around longlines, persistently investigated baited hooks, and attacked dead or dying tuna before they were hauled in (Bullis 1955; Backus *et al.* 1956). In fact, the sharks were so persistent, even attempts to drive them away via the use of underwater explosives were unsuccessful (Backus *et al.* 1956).

Rigby *et al.* (2019a) used a Bayesian state-space tool for trend analysis of abundance indices (Just Another Red List Assessment or JARA) to determine a global abundance trend for the oceanic whitetip shark. The estimated area-weighted global population trend was a decline of 98-100%, with the highest probability of 80-99% reduction over three generation lengths (61.2 years based on IUCN criteria). However, it should be noted that there was no abundance data that spanned over three generations and the decline was based on the projected trend from the current observed data (NMFS 2023c). Evaluating bycatch data available since the 1990s, the species has declined by at least 75% throughout its range (Pacoureau *et al.* 2021) and at similarly high levels in all regions (NMFS 2024d).

Recent information suggests the species is now relatively rare in the North Atlantic and large population declines have been reported, although there has been significant debate regarding the magnitude (Burgess *et al.* 2005 a,b). Declines in abundance from the 1990s to the early 2000s have ranged from 9% to 70% depending on the data source and area (Baum *et al.* 2003; Cortés *et al.* 2007; Baum and Blanchard 2010). The most significant decline reported was a 99.9% decrease in abundance in the Gulf of America since the 1950s based on a comparison of longline research surveys from 1954-1957 and data from fisheries observers collected on commercial pelagic longline sets from 1995-1999. However, the claim of such drastic declines was criticized for a lack of understanding of data, and for not taking into consideration the increase in the average depth of sets and the discontinued use of wire leaders that could have reduced catchability (Burgess *et al.* 2005a,b). The Food and Agriculture Organization of the United Nations (FAO) (2012) utilized data from Driggers *et al.* (2011) to demonstrate the catch rates of Baum and Myers (2004) for the recent period would have been 0.55 sharks per 1000 hook-hours rather than 0.02 per 1000 hook-hours when using wire leaders. Comparing the recent 0.55 value with the Baum and Myers (2004) of 4.62 for the 1950s gives an estimated extent of decline of 88%.

An analysis of the most recent observer data (subset to reflect the statistical grids of highest occurrence for oceanic whitetip shark) from the U.S. Northwest Atlantic Pelagic Longline

Fishery from 1992-2018 indicated a 2% decline in abundance over the length of the time series (Figure 39). Thus, while it is likely that significant historical declines occurred, it appears that the population in the Northwest Atlantic may have stabilized with some evidence of recent increases in abundance since 2010. Although not confirmed, this may be due to management actions implemented in 1993, including the first Federal Fishery Management Plan for Sharks (NMFS 1993), and subsequent regulations that include trip limits, quotas, time and area closures, and gear restrictions.

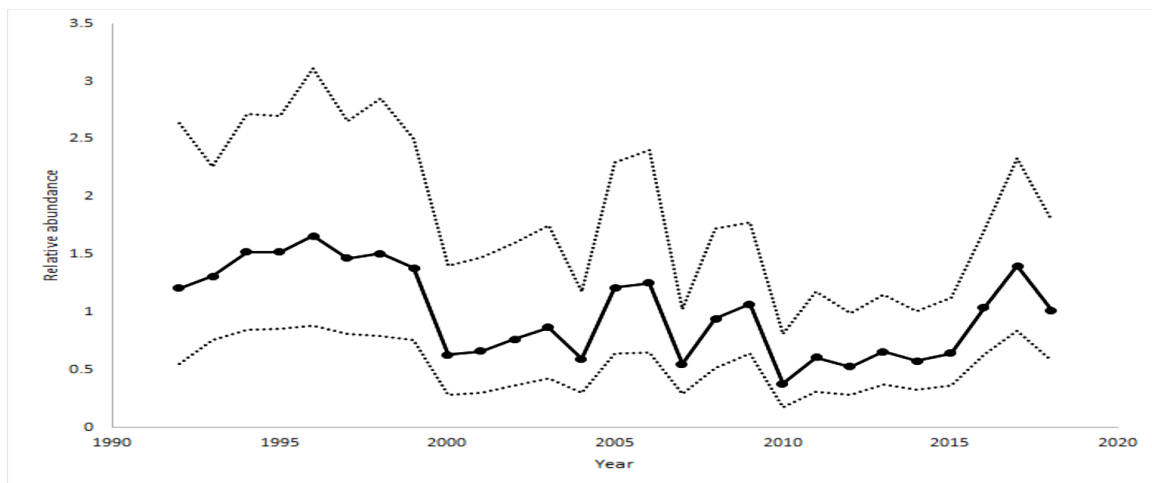


Figure 39. Estimated Change in Relative Abundance (standardized catch per 1,000 hooks) between 1992 and 2019 based on the Northwest Atlantic Pelagic Longline Observer Data for Oceanic Whitetip Sharks (Source: NMFS Observer Database)

Overall, evidence (both quantitative and qualitative) suggests that while oceanic whitetip sharks were once considered to be one of the most abundant and commonly encountered pelagic shark species wherever it occurred, this oceanic species has likely undergone population abundance declines of varying but likely significant magnitudes throughout its global range. While it is likely that significant historical declines occurred in the Northwest Atlantic, it appears that the population there may have stabilized with some evidence of recent increases in abundance since 2010 (Young and Carlson 2020).

While there is limited research on the genetic diversity of oceanic whitetip sharks, that which exists indicates low genetic diversity. Compared to other pelagic sharks (e.g., silky sharks (*Carcharhinus falciformis*), oceanic whitetip sharks display relatively low mitochondrial DNA genetic diversity (Clarke et al. 2015; Camargo et al. 2016; Ruck 2016). As noted previously, the species appears to display a high degree of philopatry to certain sites, with females giving birth on one side of a basin or the other, indicating little if any mixing with individuals of other regions (Howey-Jordan et al. 2013; Tolotti et al. 2015; Young et al. 2017). Thermal barriers (i.e., water temperatures less than 15° Celsius) may prevent inter-ocean basin movements. Nuclear and mitochondrial DNA demonstrate genetic differentiation between samples collected in the Atlantic and Indo-Pacific Oceans (Ruck 2016; Ruck et al. 2024). There may also be additional substructure (e.g., mitochondrial differentiation between the eastern and western Atlantic Ocean (Ruck et al. 2024).

In the Western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of America. Essential Fish Habitat for the oceanic whitetip shark includes localized areas in the central Gulf of America and Florida Keys, and depths greater than 200 m in the Atlantic (from southern New England to Florida, Puerto Rico, and the U.S. Virgin Islands). In the Northwest Atlantic, historically the species was widespread, abundant, and the most common pelagic shark warm waters (Backus et al. 1956). However, recent information suggests the species is now relatively rare in this region (Young et al. 2017).

Hearing

Oceanic whitetip sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Myrberg et al. 1978; Myrberg 2001; Hastings and Popper 2005; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001).

Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Myrberg 2001; Casper et al. 2003; Casper 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). Studies involving oceanic whitetip sharks show attraction to low frequency sounds, particularly those between 25 and 50 Hz, with less but still noticeable attraction at higher frequencies between 500 and 1,000 Hz (Myrberg et al. 1975; Myrberg et al. 1976; Myrberg et al. 1978; Myrberg 2001).

Status

In addition to declines in oceanic whitetip catches throughout its range, there is also evidence of declining average size over time in some areas, and is a concern for the species' status given evidence that litter size is potentially correlated with maternal length. Such extensive declines in the species' global abundance and the ongoing threat of overutilization, the species' slow growth and relatively low productivity, makes them generally vulnerable to depletion and potentially slow to recover from overexploitation. The biology of the oceanic whitetip shark indicates that it is likely to be a species with low resilience to fishing and minimal capacity for compensation (Rice and Harley 2012).

Numerous regulatory mechanisms exist to deter retention, modify gear, and ensure proper handling; and recent data suggest declining mortality rates in pelagic fisheries, especially in the Atlantic and Pacific Oceans (Worm et al. 2024). Retaining, landing, storing, selling and transshipping of whole or any part of oceanic whitetip sharks is now prohibited in fisheries jurisdictions governed by all major tuna Regional Fisheries Management Organizations (Fields et al. 2025). Since late 2014 the species has been listed on Appendix II of the CITES, which means any international trade must be accompanied by an export permit certifying that the 'take' is not a threat to the species survival in the wild. However, illegal trade of oceanic whitetip sharks, particularly for the dried fin markets in China, remains an ongoing threat to the

conservation of this species (NMFS 2023e; Fields et al. 2025). Recent evidence suggests that most populations are still declining due to continued fishing pressure and associated mortality (NMFS 2024e). The most recent NMFS 5-year status review (NMFS 2025a) reaffirmed that the oceanic whitetip shark is likely to become an endangered species within the foreseeable future throughout its range because of habitat modification, overutilization, inadequate regulatory mechanisms, and manmade factors.

Critical Habitat

No critical habitat has been designated for the oceanic whitetip shark.

Recovery Goals

The three recovery objectives for the oceanic whitetip shark (NMFS 2024c) are to:

- Ensure the oceanic whitetip shark maintains resiliency and geographic representation, and is a functional component of the ecosystem, by increasing overall abundance to achieve viable populations in all ocean basins;
- Increase oceanic whitetip shark resiliency by managing or eliminating significant anthropogenic threats; and
- Ensure the continued viability of the oceanic whitetip shark through development and effective implementation of regulatory mechanisms for the long-term protection of the species.

4.2.17 Scalloped Hammerhead Shark – Central and Southwest Atlantic DPS

Scalloped hammerheads were originally listed July 3, 2014 (79 FR 38213). Four scalloped hammerhead shark DPSs were listed and assigned status to endangered Eastern Atlantic DPS, endangered Eastern Pacific DPS, threatened Central and Southwest Atlantic DPS, and threatened Indo-West Pacific DPS. NMFS found there were no marine areas within the jurisdiction of the United States that met the definition of critical habitat for three of the DPSs: the Central and Southwest Atlantic DPS, Indo-West Pacific DPS, or Eastern Pacific DPS. The fourth DPS—the Eastern Atlantic DPS—only occurs outside of U.S. jurisdiction, and critical habitat cannot be considered for that DPS (80 FR 71774, November 17, 2015). Of the ESA-listed DPSs, only the Central and Southwest Atlantic DPS is found in the action area (Figure 40). Scalloped hammerheads are moderately large coastal pelagic sharks found worldwide in coastal warm temperate and tropical seas in the Atlantic, Pacific and Indian Oceans between 46°N and 36°S (Miller et al. 2014)

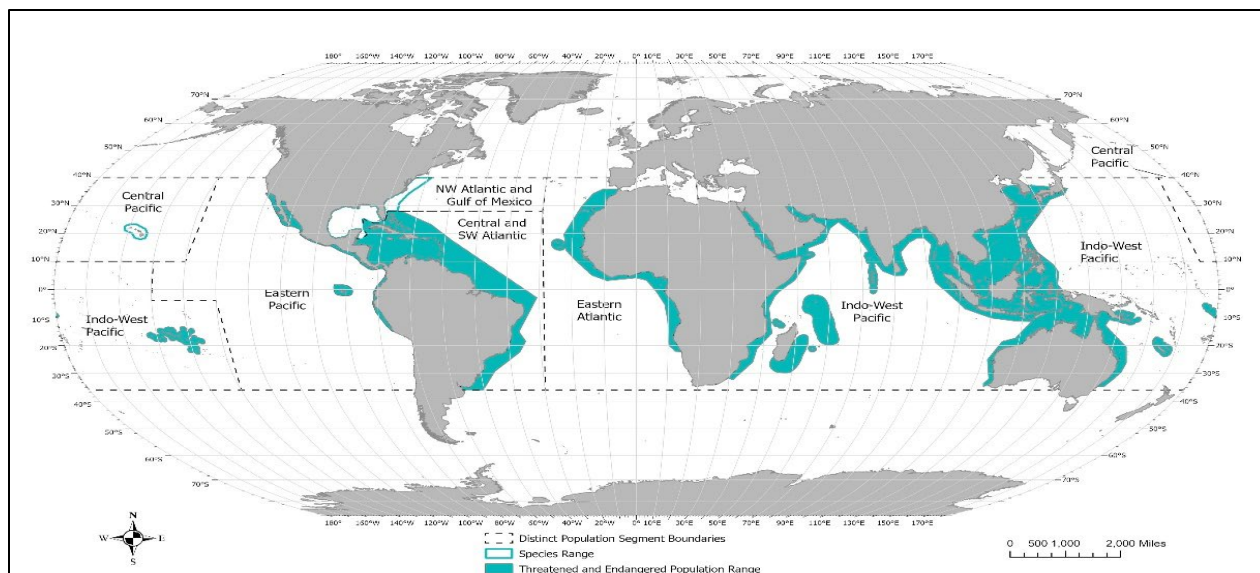


Figure 40. Range and DPS Delineation for the Scalloped Hammerhead Shark

Hammerhead sharks are recognized by their laterally expanded head that resembles a hammer, hence the common name “hammerhead.” The scalloped hammerhead shark is distinguished from other hammerheads by a noticeable indentation on the center and front portion of the head, along with two more indentations on each side of this central indentation, giving the head a “scalloped” appearance. It has a broadly arched mouth and the back of the head is slightly swept backward.

Life History

The scalloped hammerhead shark gives birth to live young (i.e., “viviparous”), with a gestation period of nine to 12 months (Branstetter 1987; Stevens and Lyle 1989) which may be followed by a one-year resting period (Liu and Chen 1999). Females attain maturity around 2.0 to 2.5 m in length, while males reach maturity at smaller sizes between 1.3 to 2.0 m. The age at maturity differs by region. For example, in the Gulf of America, Branstetter (1987) estimated that females mature at about 15 years of age and males at around nine to 10 years of age. In northeastern Taiwan, Chen et al. (1990) calculated age at maturity to be four years for females and 3.8 years for males. On the east coast of South Africa, age at sexual maturity for females was estimated at 11 years (Dudley and Simpfendorfer 2006). Parturition, however, does not appear to vary by region and may be partially seasonal (Harry et al. 2011), with neonates present year round but with abundance peaking during the spring and summer months (Duncan and Holland 2006; Adams and Paperno 2007; Harry et al. 2011; Noriega et al. 2011). Off the coast of northeastern Australia, Noriega et al. (2011) found a positive correlation between litter size and female shark length, as did White et al. (2008) in Indonesian waters. However, off the northeastern coast of Brazil, Hazin et al. (2001) found no such relationship. Size at birth is estimated between 0.3 to 0.6 m. Rigby et al. (2019) summarized the literature on age and growth from various populations. Scalloped hammerheads reach a maximum size of 370–420 cm total length (TL). Males mature at smaller sizes between 140–198 cm TL compared to females at 200–250 cm TL. Females mature at 13.2 years (see below) and live up to 35 years. They give birth annually with a litter size from 12-41 pups and generation length is 24.1 years (Rigby et al. 2019).

Scalloped hammerheads are found over continental shelves and the shelves surrounding islands, as well as adjacent deep waters, but is seldom found in waters cooler than 22° Celsius (Compagno 1984; Schulze-Haugen and Kohler 2003). They range from the intertidal and surface to depths of up to 450-512 m (Klimley 1993), with occasional dives to even deeper waters (Jorgensen et al. 2009). They have also been documented entering enclosed bays and estuaries (Compagno 1984). Neonates and juveniles inhabit nearshore nursery habitats for up to one year or more as these areas provide valuable refuge from predation (Duncan and Holland 2006). They are high trophic level, opportunistic predators whose diet includes crustaceans, fish and cephalopods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Central and Southwest Atlantic DPS of Scalloped Hammerhead sharks.

Scalloped hammerhead sharks are highly mobile and partly migratory and are likely the most abundant of the hammerhead species (Maguire 2006); however the risk of local depletions is of concern. Scalloped hammerhead sharks have a life history that is susceptible to overharvesting, and according to the most recent stock assessment the Northwestern Atlantic and Gulf of Mexico stock has declined to a relatively low level of abundance in recent years (Hayes et al. 2009). Populations in other parts of the world are assumed to have suffered similar declines, however data to conduct stock assessments on those populations are currently lacking. Central and Southwest Atlantic DPS.

A 61.7% decline in CPUE of hammerheads was estimated for longline vessels operating in the south Atlantic from 1998 to 2007 (Rigby et al. (2019b) Table S11; citing Barreto *et al.* 2016). The majority of the fleet effort overlapped with the Central and Southwest Atlantic DPS, but some effort also was within the boundaries of the Eastern Atlantic DPS (Figure 41).

Miller et al. (2014) considered Brazilian longline catch data in their extinction risk analysis and reported peak catches in 2002 (508 tonnes) with significant declines by 2009 (88 tonnes).

Rooker et al. (2019) assessed movement of scalloped hammerheads electronically tagged in the U.S. waters of the Gulf of America from 2012 to 2016. They found that scalloped hammerheads displayed prolonged periods of residency (99% of daily positions) in the northern Gulf of America in U.S. waters with limited displacement to Mexico (~ 1% or less) and none to Cuba.

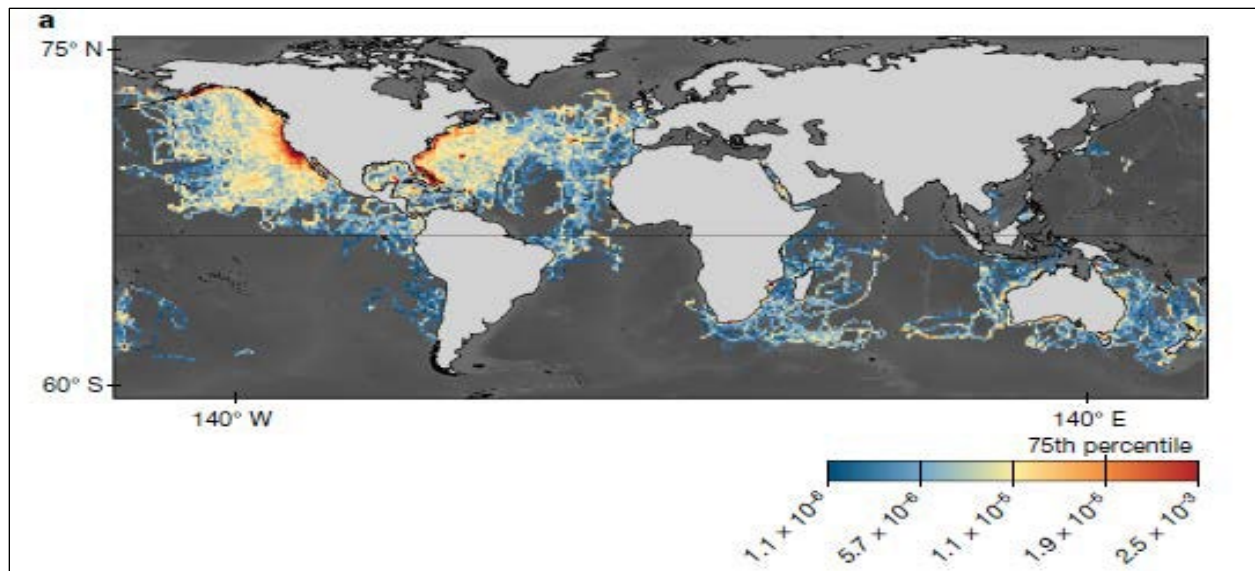


Figure 41. Relative Global Density of Scalloped Hammerhead Sharks (Queiroz et al. 2019)

Liver tissue samples from scalloped hammerheads captured off the southeastern U.S. Atlantic coast showed that pregnant females transferred a substantial amount of contaminants (0.48–0.66 g of Polychlorinated biphenyls (PCBs) and 0.14–0.39 g of dichlorodiphenyltrichloroethane (DDT) representing approximately 0.03–2.3% of the concentration in the hepatic tissue) to their offspring. Potential health impacts are unknown and further research is needed to understand potential effects on shark physiology (Lyons and Adams 2015).

Scalloped hammerheads collected (n = 10) from two commercial fish landing sites in Trinidad had levels of mercury, arsenic, cadmium, and lead in vertebrae, muscle, fin, and liver tissue that would pose a health risk to consumers over long term exposure (Mohammed and Mohammed 2017). The effect, if any, of these contaminants to scalloped hammerheads needs further research.

At the time we listed the Central and Southwest Atlantic DPS of scalloped hammerhead shark, it was thought to occur within the U.S. Caribbean (79 FR 38213, Publication Date July 3, 2014). However, in designating critical habitat for the Central and Southwest Atlantic DPS of scalloped hammerhead shark the following year (80 FR 71774, Publication Date November 17, 2015), we determined that there is no evidence that the scalloped hammerhead shark was present within the waters of the U.S. Caribbean.

Since that time, we have received additional information indicating that this species does occur in waters of the U.S. Caribbean. In connection with our consultation on fishery independent monitoring in the U.S. Caribbean, we learned of a single recorded interaction during hook-and-line fishery monitoring (NMFS 2016a), and are now aware of a limited number of additional interactions. For purposes of this Opinion, we believe that the Central and Southwest Atlantic DPS of scalloped hammerhead shark is found in waters of the U.S. Caribbean, among other areas. Therefore, we consider effects to this DPS only in waters off Puerto Rico. Data from the Marine Recreational Information Program (MRIP) from Puerto Rico from 2001 – 2016 show

797 scalloped hammerhead sharks were landed by recreational charter boats using vertical line gear within Puerto Rico's territorial waters, which extend to 9 nm from shore. The greatest number of scalloped hammerhead sharks, 516, were captured in 2003. The other landings were from 2004 (44), 2006 (30), 2012 (98), and 2016 (109). Landed sharks ranged in length from 600 – 800 mm, meaning they were likely neonates or juveniles as maturity is reached when males are approximately 1,219 mm and females are 1,981 mm. At least some of the sharks may have been misidentified and were actually bonnetheads. Others were included in a general hammerhead shark category and could be species other than scalloped hammerhead (M. Wunderlich, NMFS SERO, pers. comm. to L. Carrubba, NMFS OPR, October 13, 2017). Adult sharks tend to be more common in offshore waters while neonates and juveniles are more common in nearshore waters in areas where they occur. There are limited data from the U.S. Caribbean indicating that two bays, one in St. Thomas and one in St. John, USVI serve as nursery habitat for neonate scalloped hammerhead sharks (DeAngelis 2006).

Hearing

Scalloped hammerhead sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Myrberg 2001; Hastings and Popper 2005; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swimbladders, and thus are unable to detect sound pressure (Casper et al. 2012). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001).

Data for elasmobranchs fishes, including scalloped hammerheads, suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Olla 1962; Myrberg 1978; Myrberg 2001; Casper et al. 2003; Casper 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). A study involving unidentified hammerhead sharks of the genus *Sphyrna*, indicates attraction to low frequency sound between 20 and 60 Hz (Nelson and Gruber 1963). However, a study specifically on scalloped hammerheads found no attraction to similar low frequency sound (Klimley and Nelson. 1981).

Status

Based on a combination of fisheries dependent and fisheries independent data, it is estimated that hammerhead shark populations have experienced drastic population declines, in excess of 90%, in several parts of their global range (Gallagher et al. 2014). While scalloped hammerhead sharks in the northwest Atlantic may currently be in a rebuilding phase, populations found further south in the Atlantic could still be in danger of decline (Miller et al. 2014). Historical landings data indicate that large numbers of hammerhead sharks were removed by longliners off the coast of Brazil in the late 20th century (Amorim et al. 1998). Although abundance estimates and quality catch data are unavailable for this DPS, the evidence of heavy fishing pressure on this species off the coast of Brazil, Central America, and the Caribbean, with documented large numbers of juvenile and neonate landings, suggests this DPS is likely approaching a level of abundance and

productivity that places its current and future persistence in question (Miller et al. 2014). Overutilization by industrial/commercial fisheries combined with high at-vessel fishing mortality were ranked by the Extinction Risk Analysis team as the greatest risks to the persistence of this DPS. Overutilization by artisanal fisheries, lack of adequate regulatory mechanisms, illegal, unreported and unregulated fishing, and the schooling behavior of the species were ranked as moderate risks.

Critical Habitat

In 2015 NMFS determined that there are no marine areas within the jurisdiction of the U.S. that meet the definition of critical habitat for the Central and Southwest Atlantic DPS (80 FR 71774, Publication Date November 17, 2015; <https://www.federalregister.gov/d/2015-29262>).

Recovery Goals

NMFS has not prepared a recovery plan for the scalloped hammerhead shark.

4.2.18 Smalltooth Sawfish – United States Portion of Range DPS

The smalltooth sawfish is a tropical marine and estuarine elasmobranch. Within the United States, smalltooth sawfish have been captured in estuarine and coastal waters from New York southward through Texas, although peninsular Florida has historically been the region of the United States with the largest number of recorded captures (NMFS 2010c) (Figure 42).

Although they are rays, sawfish physically resemble sharks, with only the trunk and especially the head ventrally flattened. Smalltooth sawfish are characterized by their “saw,” a long, narrow, flattened rostral blade with a series of transverse teeth along either edge. The U.S. DPS of smalltooth sawfish was listed as endangered under the ESA effective May 1, 2003.

Life History

Smalltooth sawfish size at sexual maturity has been reported as 360 cm total length by Simpfendorfer (2005). Kroetz et al. (2025) estimated median age at maturity for smalltooth sawfish in Florida as 6.9 years for males and 7.9 years for females. Smalltooth sawfish are viviparous with fertilization being internal. The gestation period for smalltooth sawfish is estimated at five months based on data from the largetooth sawfish (Thorson 1976). Females move into shallow estuarine and nearshore nursery areas to give birth to live young between November and July, with peak parturition occurring between April and May (Poulakis et al. 2011). Litter sizes range between 10 and 20 individuals (Bigalow and Schroeder 1953; Simpfendorfer 2005; Carlson and Simpfendorfer 2015).

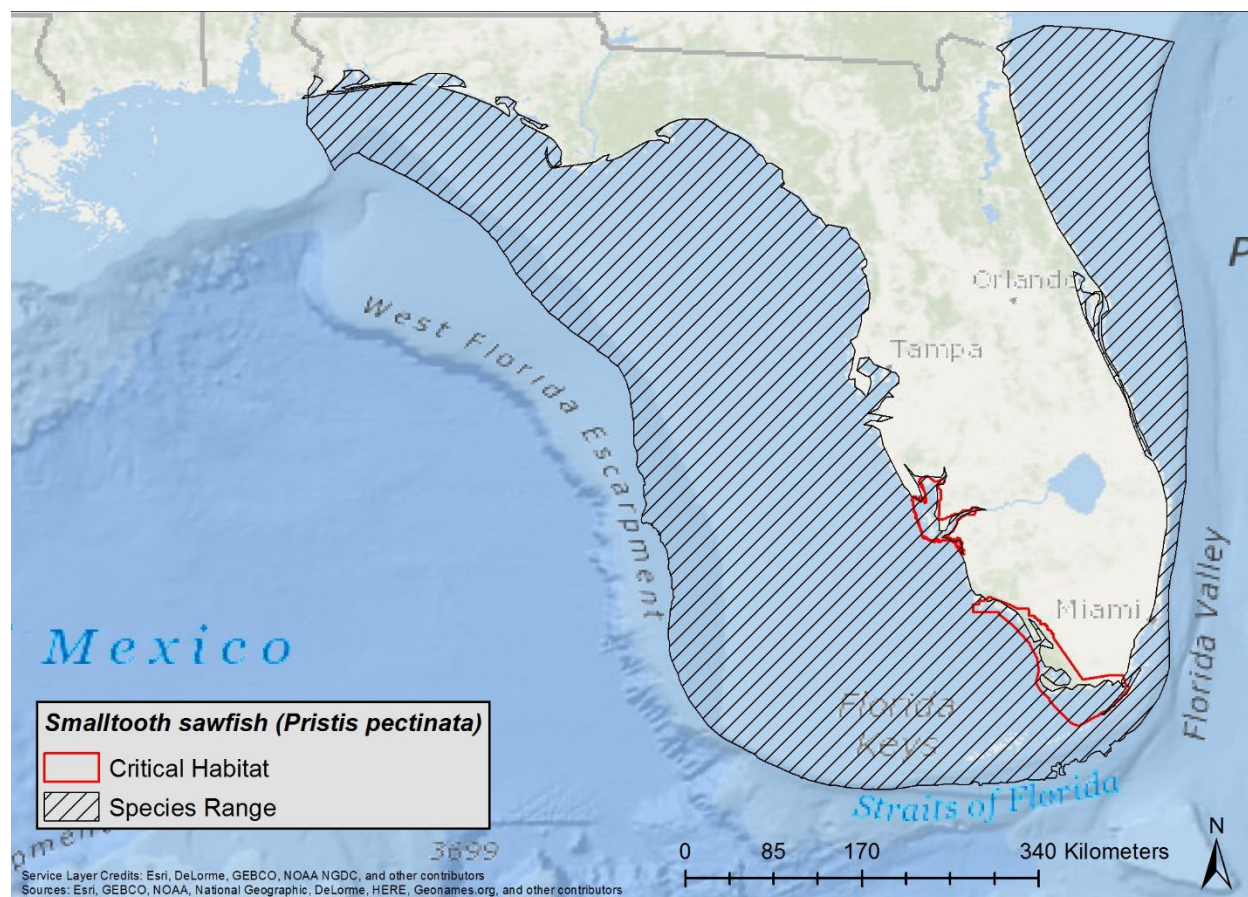


Figure 42. Map Depicting the Range and Designated Critical Habitat for the U. S. DPS of Smalltooth Sawfish

Neonate smalltooth sawfish are born measuring 67 to 81 cm total length and spend the majority of their time in the shallow nearshore edges of sand and mud banks (Simpfendorfer et al. 2010; Poulakis et al. 2011). Once individuals reach 100 to 140 cm total length, they begin to expand their foraging range. Capture data suggests smalltooth sawfish in this size class may move throughout rivers and estuaries within a salinity range of 18 and 30 (practical salinity units). Individuals in this size class also appear to have the highest affinity to mangrove habitat (Simpfendorfer et al. 2011). Juvenile sawfish spend the first two to three years of their lives in the shallow waters provided in the lower reaches of rivers, estuaries, and coastal bays (Simpfendorfer et al. 2008; Simpfendorfer et al. 2011). Smalltooth sawfish grow rapidly in their first three years, reaching 235 cm stretch total length (Kroetz et al. 2025). As smalltooth sawfish approach 250 cm total length they become less sensitive to salinity changes and begin to move out of the protected shallow-water embayments and into the shorelines of barrier islands (Poulakis et al. 2011). Adult smalltooth sawfish typically occur in more open-water, marine habitats (Poulakis and Seitz 2004). Smalltooth sawfish life-spans can exceed 30 years, and the annual natural mortality rate for this species is estimated to be between 0.151 and 0.278 on the basis of life history surrogates (Kroetz et al. 2025).

Population Dynamics

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

The abundance of smalltooth sawfish in U.S. waters has decreased dramatically over the past century. Efforts are currently underway to provide better estimates of smalltooth sawfish abundance (NMFS 2014a). Current abundance estimates are based on encounter data, genetic sampling, and geographic extent. Carlson and Simpfendorfer (2015) used encounter densities to estimate the female population size to be 600. Chapman et al. (2011) analyzed genetic data from tissue samples (fin clips) to estimate the effective genetic population size as 250 to 350 adults (95% confidence interval from 142 to 955). Simpfendorfer (2002) estimated that the U.S. population may number less than 5% of historic levels based on the contraction of the species' range.

The abundance of juveniles encountered in recent studies suggests that the smalltooth sawfish population remains reproductively viable (Seitz and Poulakis 2002; Simpfendorfer and Wiley 2004; Poulakis et al. 2014). The overall abundance appears to be stable (Wiley and Simpfendorfer 2010). Data analyzed from the Everglades portion of the smalltooth sawfish range suggests that the population growth rate for that region may be around 5% per year (Carlson et al. 2007; Carlson and Osborne 2012). Intrinsic rates of growth for smalltooth sawfish have been estimated at 1.08 to 1.14 per year and 1.237 to 1.150 per year by Simpfendorfer (2000) and Carlson and Simpfendorfer (2015) respectively. However, these intrinsic rates are uncertain due to the lack of long-term abundance data.

Chapman et al. (2011) investigated the genetic diversity within the smalltooth sawfish population. The study reported that the remnant population exhibits high genetic diversity (allelic richness, alleles per locus, heterozygosity) and that inbreeding is rare. The study also suggested that the protected population will likely retain greater than 90% of its current genetic diversity over the next century.

Recent capture and encounter data suggest that the current distribution is focused primarily to south and southwest Florida from Charlotte Harbor through the Dry Tortugas (Seitz and Poulakis 2002; Poulakis and Seitz 2004). Water temperatures (no lower than 16° to 18° Celsius) and the availability of appropriate coastal habitat (shallow, euryhaline waters and red mangroves) are the major environmental constraints limiting the distribution of smalltooth sawfish (Bigelow and Schroeder 1953).

Vocalization and Hearing

Smalltooth sawfish are elasmobranchs, and although there is no known information on their sound production and hearing abilities, these abilities have been studied in other elasmobranchs species. Elasmobranchs, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and

thus are unable to detect sound pressure (Casper et al. 2012). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001). Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Myrberg 2001; Casper et al. 2003; Casper 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013).

Status

The decline in the abundance of smalltooth sawfish has been attributed to fishing (primarily commercial and recreational bycatch), habitat modification (including changes to freshwater flow regimes as a result of changing environmental conditions), and life history characteristics (i.e., slow-growing, relatively late-maturing, and long-lived species) (NMFS 2009a; Simpfendorfer et al. 2011). These factors continue to threaten the U.S. DPS of smalltooth sawfish. In late 2023 the Florida Fish and Wildlife Conservation Commission began receiving reports of “spinning” sawfish from the Florida Keys, and smalltooth sawfish mortalities were first reported in January 2024. As of late March 2024, about 109 smalltooth sawfish have been affected and 28 mortalities have been documented. Officials are still investigating the cause of this unusual mortality event but the best evidence so far points to harmful algal blooms.

Recent records indicate there is a resident reproducing population of smalltooth sawfish in south and southwest Florida from Charlotte Harbor through the Dry Tortugas, which is also the last U.S. stronghold for the species (Seitz and Poulakis 2002; Poulakis and Seitz 2004; Simpfendorfer and Wiley 2004). This population is likely stable or increasing (Carlson and Osborne 2012; Carlson and Simpfendorfer 2015). While the overall abundance appears to be stable, low intrinsic rates of population increase suggest that the species is particularly vulnerable to rapid population declines (NMFS 2010c).

Critical Habitat

Smalltooth sawfish designated critical habitat does not overlap with the action area or any stressors resulting from the proposed action.

Recovery Goals

The 2009 Smalltooth Sawfish Recovery Plan (NMFS 2009a) contains complete downlisting/delisting criteria for each of the three following recovery goals:

- Minimize human interactions and associated injury and mortality.
- Protect and/or restore smalltooth sawfish habitats.
- Ensure smalltooth sawfish abundance increases substantially and the species reoccupies areas from which it had been previously extirpated.

4.2.19 Corals – General Threats

There are seven species of Caribbean and Florida ESA-listed corals: Staghorn (*Acropora cervicornis*), Elkhorn (*A. palmata*), Pillar (*Dendrogyra cylindrus*), Lobed Star (*Orbicella annularis*), Mountainous Star (*O. faveolata*), Boulder Star (*O. franksi*), and Rough Cactus (*Mycetophyllia ferox*) that occur on shallow coral reefs within the Caribbean, Atlantic and Gulf of America along the Florida coast, overlapping the proposed action area. Due to their broad distribution and sessile nature, these species may occur within the action area. This section addresses the general threats to all coral species. The following sections will address the distribution, life history, population structure, abundance, population trends, and unique threats to each species of coral.

Corals face numerous natural and man-made threats that shape their status and affect their ability to recover. Many of the threats are either the same or similar in nature for all listed coral species, those identified in this section are discussed in a general sense for all corals. All threats are expected to increase in severity in the future. More detailed information on the threats to listed corals is found in the Final Listing Rule (79 FR 53851; September 10, 2014). Threat information specific to a particular species is then discussed in the corresponding status sections where appropriate.

Several of the most important threats contributing to the extinction risk of corals are related to changing environmental conditions. The main concerns regarding impacts of environmental changes on coral reefs generally, and on listed corals in particular, are the magnitude and the rapid pace of change in greenhouse gas (GHG) concentrations (e.g., carbon dioxide [CO₂] and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming rate of environmental systems and altering the carbonate chemistry of the ocean (ocean acidification). Ocean acidification affects a number of biological processes in corals, including secretion of their skeletons.

Ocean Warming

Ocean warming is one of the most important threats posing extinction risks to the listed coral species, but individual susceptibility varies among species. The primary observable coral response to ocean warming is bleaching of adult coral colonies, wherein corals expel their symbiotic algae in response to stress. For many corals, an episodic increase of only 1°C–2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, and/or prolonged bleaching can lead to colony death. Coral bleaching patterns are complex, with several species exhibiting seasonal cycles in symbiotic algae density. Thermal stress has led to bleaching and mass mortality in many coral species during the past 25 years.

In addition to coral bleaching, other effects of ocean warming can harm virtually every life-history stage in reef-building corals. Impaired fertilization, developmental abnormalities, mortality, impaired settlement success, and impaired calcification of early life phases have all been documented. Average seawater temperatures in reef-building coral habitat in the wider Caribbean have increased during the past few decades and are predicted to continue to rise

between now and 2100. Further, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past 2 decades and is predicted to continue to increase between now and 2100.

Ocean Acidification

Ocean acidification is a result of changing environmental conditions caused by increased CO₂ in the atmosphere that results in greater releases of CO₂ that is then absorbed by seawater. Reef-building corals produce skeletons made of the aragonite form of calcium carbonate. Ocean acidification reduces aragonite concentrations in seawater, making it more difficult for corals to build their skeletons. Ocean acidification has the potential to cause substantial reduction in coral calcification and reef cementation. Further, ocean acidification impacts adult growth rates and fecundity, fertilization, pelagic planula settlement, polyp development, and juvenile growth. Ocean acidification can lead to increased colony breakage, fragmentation, and mortality. Based on observations in areas with naturally low pH, the effects of increasing ocean acidification may also include reductions in coral size, cover, diversity, and structural complexity.

As CO₂ concentrations increase in the atmosphere, more CO₂ is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in CO₂ and other GHGs in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean, and is predicted to increase considerably between now and 2100. Along with ocean warming and disease, we consider ocean acidification to be one of the most important threats posing extinction risks to coral species between now and the year 2100, although individual susceptibility varies among the listed corals.

Diseases

Disease adversely affects various coral life history events by, among other processes, causing adult mortality, reducing sexual and asexual reproductive success, and impairing colony growth. A diseased state results from a complex interplay of factors including the cause or agent (e.g., pathogen, environmental toxicant), the host, and the environment. All coral disease impacts are presumed to be attributable to infectious diseases or to poorly-described genetic defects. Coral disease often produces acute tissue loss. Other forms of "disease" in the broader sense, such as temperature-caused bleaching, are discussed in other threat sections (e.g., ocean warming as a result of changing environmental conditions).

Coral diseases are a common and significant threat affecting most or all coral species and regions to some degree, although the scientific understanding of individual disease causes in corals remains very poor. The incidence of coral disease appears to be expanding geographically, though the prevalence of disease is highly variable between sites and species. Increased prevalence and severity of diseases is correlated with increased water temperatures, which may correspond to increased virulence of pathogens, decreased resistance of hosts, or both. Moreover, the expanding coral disease threat may result from opportunistic pathogens that become damaging only in situations where the host integrity is compromised by physiological stress or immune suppression. Overall, there is mounting evidence that warming temperatures

and coral bleaching responses are linked (albeit with mixed correlations) with increased coral disease prevalence and mortality.

Trophic Effects of Reef Fishing

Fishing, particularly overfishing, can have large-scale, long-term ecosystem-level effects that can change ecosystem structure from coral-dominated reefs to algal-dominated reefs (“phase shifts”). Even fishing pressure that does not rise to the level of overfishing potentially can alter trophic interactions that are important in structuring coral reef ecosystems. These trophic interactions include reducing population abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control.

In the Caribbean, parrotfishes can graze at rates of more than 150,000 bites per square m per day (Carpenter 1986), and thereby remove up to 90-100% of the daily primary production (e.g., algae; Hatcher 1997). With substantial populations of herbivorous fishes, as long as the cover of living coral is high and resistant to mortality from environmental changes, it is very unlikely that the algae will take over and dominate the substrate. However, if herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished and a major mortality of coral colonies occurs, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (e.g., overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substrate by planula larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae can block successful colonization of the bottom by corals because the macroalgae takes up the available space and causes shading, abrasion, chemical poisoning, and infection with bacterial disease. Trophic effects of fishing are a medium importance threat to the extinction risk for listed corals.

Sedimentation

Human activities in coastal and inland watersheds introduce sediment into the ocean by a variety of mechanisms including river discharge, surface runoff, groundwater seeps, and atmospheric deposition. Humans also introduce sewage into coastal waters through direct discharge, treatment plants, and septic leakage. Elevated sediment levels are generated by poor land use practices and coastal and nearshore construction.

The most common direct effect of sedimentation is sediment’s landing on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments. In addition, corals can actively remove sediment but at a significant energy cost. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. Some coral species can tolerate complete burial for several days. Corals that cannot remove sediment will be smothered and die. Sediment can also cause sublethal effects such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in

the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles.

Nutrient Enrichment

Elevated nutrient concentrations in seawater affect corals through 2 main mechanisms: direct impacts on coral physiology, and indirect effects through stimulation of other community components (e.g., macroalgal turfs and seaweeds, and filter feeders) that compete with corals for space on the reef. Increased nutrients can decrease calcification; however, nutrients may also enhance linear extension while reducing skeletal density. Either condition results in corals that are more prone to breakage or erosion, but individual species do have varying tolerances to increased nutrients. Anthropogenic nutrients mainly come from point-source discharges (such as rivers or sewage outfalls) and surface runoff from modified watersheds. Natural processes, such as *in situ* nitrogen fixation and delivery of nutrient-rich deep water by internal waves and upwelling, also bring nutrients to coral reefs.

4.2.20 Elkhorn Coral

Elkhorn coral was listed as threatened under the ESA in May 2006 (71 FR 26852). In December 2012, NMFS proposed changing its status from threatened to endangered (77 FR 73219). On September 10, 2014, NMFS determined that elkhorn coral should remain listed as threatened (79 FR 53851). Elkhorn coral (*Acropora palmata*) occurs throughout coastal areas in the Caribbean, Gulf of America, and southwestern Atlantic (Figure 43).

Elkhorn coral colonies have frond-like branches, which appear flattened to near round, and typically radiate out from a central trunk and angle upward. Branches are up to approximately 20 in (50 cm) wide and range in thickness from about 1.5-2 in (4 to 5 cm). Individual colonies can grow to at least 6.5 ft (2 m) in height and 13 ft (4 m) in diameter (Acropora Biological Review Team 2005). Colonies of elkhorn coral can grow in nearly single-species, dense stands and form an interlocking framework known as thickets.

Elkhorn coral is distributed throughout the western Atlantic Ocean, Caribbean Sea, and Gulf of America. The northern extent of the range in the Atlantic is Broward County, Florida, where it is relatively rare (only a few known colonies), but fossil elkhorn coral reef framework extends into Palm Beach County, Florida. There are 2 known colonies of elkhorn coral, which were discovered in 2003 and 2005, at the Flower Garden Banks, which is located 100 miles (161 km) off the coast of Texas in the Gulf of America (Zimmer et al. 2006). The species has been affected by extirpation from many localized areas throughout its range (Jackson et al. 2014).

Goreau (1959) described 10 habitat zones on a Jamaican fringing reef from inshore to the deep slope, finding elkhorn coral in 8 of the 10 zones. Elkhorn coral commonly grows in turbulent water on the fore-reef, reef crest, and shallow spur-and-groove zone (Shinn 1963; Cairns 1982; Rogers et al. 1982; Miller et al. 2008) in water ranging from approximately 3-15 ft (1-5 m) depth, and up to 40 ft (12 m). Elkhorn coral often grows in thickets in fringing and barrier reefs

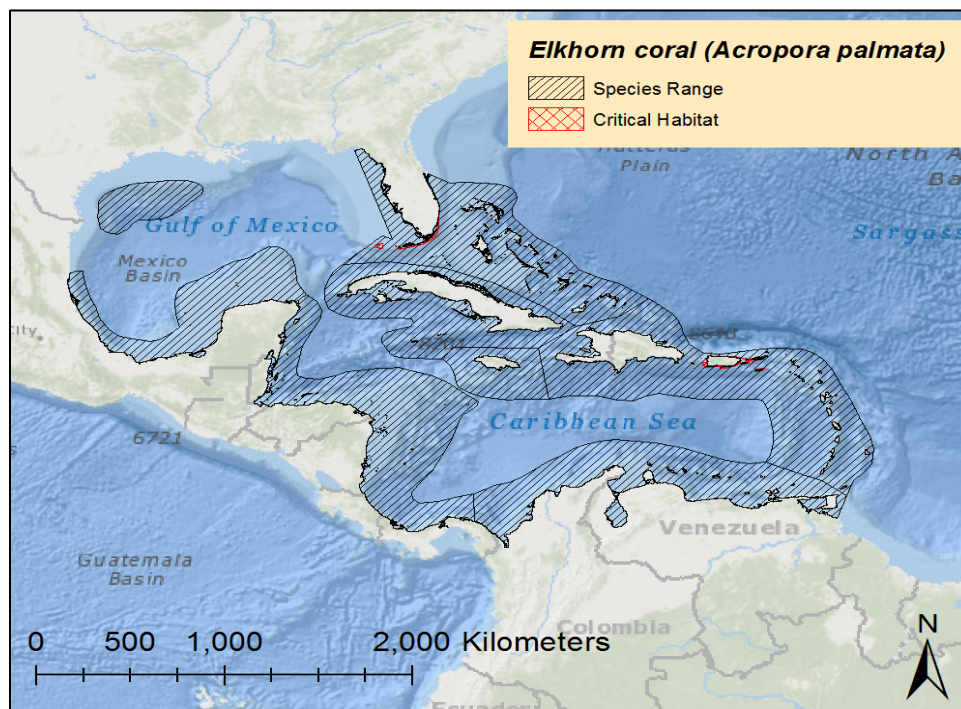


Figure 43. Range Map for Elkhorn and Staghorn Coral

(Jaap 1984; Tomascik and Sander 1987). It has formed extensive barrier-reef structures in Belize (Cairns 1982), the greater and lesser Corn Islands, Nicaragua (Lighty et al. 1982), and Roatan, Honduras and form extensive fringing reef structures throughout much of the Caribbean (Adey 1978). Early studies termed the reef crest and adjacent seaward areas from the surface down to approximately 20 ft (5-6 m) depth the “palmata zone” because of the domination by the species (Goreau 1959; Shinn 1963). It also occasionally occurs in back-reef environments and in depths up to 98 ft (30 m).

Life History

Relative to other corals, elkhorn coral has a high growth rate allowing acroporid reef growth to keep pace with past changes in sea level (Fairbanks 1989). Growth rates, measured as skeletal extension of the end of branches, range from approximately 2-4 in (4-11 cm) per year (Acropora Biological Review Team 2005). However, growth rates have been reported to be slower today than they were several decades ago (Brainard et al. 2011). Annual growth (linear extension) has been found to be dependent on the size of the colony, and new recruits and juveniles typically grow at slower rates. Additionally, stressed colonies and fragments may also exhibit slower growth.

Elkhorn coral is a hermaphroditic, broadcast spawning¹⁵ species that reproduces sexually after the full moon of July, August, and/or September, depending on location and timing of the full moon (Acropora Biological Review Team 2005). Split spawning (spawning over a 2 month

¹⁵ Simultaneously containing both sperm and eggs, which are released into the water column for fertilization.

period) has been reported from the Florida Keys (Fogarty et al. 2012). The estimated size at sexual maturity is approximately 250 in² (1,600 cm²), and growing edges and encrusting base areas are not fertile (Soong and Lang 1992). Larger colonies have higher fecundity per unit area, as do the upper branch surfaces (Soong and Lang 1992). Although self-fertilization is possible, elkhorn coral is largely self-incompatible (Baums et al. 2005; Fogarty et al. 2012). Partial mortality has a negative effect of the energy budget of elkhorn coral and reduces the quality of eggs (Piñón-González and Banaszak 2018).

Sexual recruitment rates are low, and this species is generally not observed in coral settlement studies in the field. Rates of post-settlement mortality are high based on settlement experiments (Szmant and Miller 2005; Miller 2014). Laboratory studies have found that certain species of crustose-coralline algae facilitate larval settlement and post-settlement survival (Ritson-Williams et al. 2010). Laboratory experiments have shown that some individuals (i.e., genotypes) are sexually incompatible (Baums et al. 2013; Miller et al. 2016b) and that the proportion of eggs fertilized increases with higher sperm concentration (Fogarty et al. 2012). Experiments using gametes collected in Florida and Belize showed that Florida corals had lower fertilization rates than those from Belize, possibly due to genotype incompatibilities (Fogarty et al. 2012).

Reproduction occurs primarily through asexual fragmentation that produces multiple colonies that are genetically identical (Bak and Crieens 1982; Highsmith 1982; Wallace 1985; Lirman 2000; Miller et al. 2007). Storms can be a method of producing fragments to establish new colonies (Fong and Lirman 1995). Fragmentation is an important mode of reproduction in many reef-building corals, especially for branching species such as elkhorn coral (Highsmith 1982; Wallace 1985; Lirman 2000). However, in the Florida Keys where populations have declined, there have been reports of failure of asexual recruitment due to high fragment mortality after storms (Williams et al. 2008; Williams and Miller 2010; Porter et al. 2012).

The combination of relatively rapid skeletal growth rates and frequent asexual reproduction by fragmentation can enable effective competition within, and domination of, elkhorn coral in high-energy reef environments such as reef crests. Rapid skeletal growth rates and frequent asexual reproduction by fragmentation facilitate potential recovery from disturbances when environmental conditions permit (Highsmith 1982; Lirman 2000). However, low sexual reproduction can lead to reduced genetic diversity and limits the capacity to repopulate sites distant from the parent.

Population Dynamics

Elkhorn coral was historically one of the dominant species on Caribbean reefs, forming large, monotypic thickets and giving rise to the “elkhorn” zone in classical descriptions of Caribbean reef morphology (Goreau 1959). However, mass mortality, apparently from white-band disease (Aronson and Precht 2001), spread throughout the Caribbean in the mid-1970s to mid-1980s and precipitated widespread and radical changes in reef community structure (Brainard et al. 2011). This mass mortality occurred throughout the range of the species within all Caribbean countries and archipelagos, even on reefs and banks far from localized human influence (Aronson and Precht 2001; Wilkinson 2008). In addition, continuing coral mortality from periodic acute events

such as hurricanes, disease outbreaks, and mass bleaching events added to the decline of elkhorn coral (Brainard et al. 2011). In locations where historic quantitative data are available (Florida, Jamaica, U.S. Virgin Islands), there was a reduction of greater than 97% between the 1970s and early 2000s in elkhorn coral populations (Acropora Biological Review Team 2005).

Information on elkhorn coral status and populations dynamics is spotty throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations where data exist. Current information on abundance and population trends was most recently summarized in the 5-year review of the species (NMFS 2022c).

There are benthic monitoring programs within U.S. jurisdiction that record presence, density, and percent cover of coral species, and the most recent 5-year review of the species (NMFS 2022c) summarized data trends of these unpublished data. Data from permanent monitoring stations in the Florida Keys show a decrease in mean percent cover, live tissue area, and density (0.004 colonies m^{-2} in 2014; 0.0004 colonies m^{-2} in 2019) of elkhorn coral between 2014 and 2019. During this time, one monotypic/special habitat site was monitored in the Dry Tortugas and showed more variable percent cover and live tissue area between 2014 and 2019, but values in 2019 were lower than in 2014. In contrast, density at this site was higher in 2019 (2.2 colonies per m^2) than in 2014 (1.25 colonies per m^2).

Published information indicates that declines of elkhorn coral in Florida have been steep. In the Florida Keys, density of elkhorn coral in 2014 and 2015 was 0.4-0.7 times less than density in 2005-2007; these declines occurred even with very low levels of coral outplanting at some sites (Miller et al. 2016a). Demographic monitoring of elkhorn coral populations between Carysfort and Molasses Reefs in the upper FL Keys have been ongoing since 2004. No larval recruits settled during the 15 years of study (Williams et al. 2020). Loss of genotypes has occurred both in years of disturbance and when the population appeared to be stable or increasing (2006-2010), dropping by 64% over the 15 years of study (Williams et al. 2020). Of the remaining genotypes, half (9 of 18) are incapable of spawning due to low amounts of surviving tissue. The authors conclude that elkhorn coral is already functionally extinct in the studied populations and may experience local extirpation within 6-12 years if the rate of decline is presumed to be constant. However, the rate of decline has accelerated since 2014, indicating extirpation may occur sooner (Williams et al. 2020). These patterns are similar to those seen in demographic surveys in the lower Florida Keys and in Biscayne National Park north of the upper Keys sites (Williams et al. 2020). Of the sites surveyed in the lower Keys, elkhorn coral has been extirpated at 2 sites and remains as only 2 colonies at one site. Remaining plots had catastrophic declines after a hurricane, with 3 sites having minimal recovery and one with continuing decline. There were 73 sites with elkhorn coral in the Florida Keys identified between 2003 and 2018; subsequent visits indicate potentially 42-67% of inferred genotypes at these sites (based on distance between sites) have been lost. About 120 genotypes are being propagated in coral nurseries and outplanted to multiple sites. There are no known remaining patches that have adequate numbers of synchronously spawning genets to produced viable larvae without intervention (Williams et al. 2020).

Population trends of elkhorn coral in the United States Virgin Islands appeared to be somewhat stable over the 2004 to 2014 time-frame. In a study of 10 sites in St. John, United States Virgin Islands, conducted between 2004 and 2010, elkhorn coral colony density did not significantly change over the course of the study (Muller et al. 2014). Average density was 0.027 colonies m⁻² in 2004 and 0.036 colonies m⁻² in 2010. Two sites showed a temporal shift towards more large-sized colonies (max diameter >50 cm) while 7 sites showed no change in size frequency distribution. White pox disease prevalence averaged 19% in 2004 and 3% in 2010 and was more common on large colonies (Muller et al. 2014). There is evidence of elkhorn coral population growth along 4 km of coastline in St. John, United States Virgin Islands between 1990 and 2014 (Edmunds 2014). Approximately 1,055 colonies ha⁻¹ were observed in 2014, and many of the colonies were about 15 cm diameter, suggesting they appeared within the last 5 years. Sexual recruitment was still low with only 7 recruits observed in annual surveys from 1994-2014 (Edmunds 2014).

In surveys of randomly chosen monitoring sites (different sites visited each year), unpublished monitoring data show the proportion of sites where elkhorn coral was present ranged from about 2% to 7% in the United States Virgin Islands and about 2% to 4% in Puerto Rico between 2014 and 2019. The percentage of sites where elkhorn coral was present was 0% to 2% in Florida between 2014 and 2020 with all sites containing elkhorn coral occurring in the Florida Keys. Mean maximum colony diameter ranged from approximately 30-50 cm in St. Croix, 30-75 cm in St. Thomas/St. John, and 15-50 cm in Puerto Rico. Mean partial colony mortality between 2014 and 2019 ranged from 0-35% in Puerto Rico and 5-30% in the United States Virgin Islands (NMFS 2022c).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the United States Virgin Islands in 2017. Hurricane impacts included large, overturned and dislodged coral heads and extensive burial and breakage. At 153 survey locations in Puerto Rico, approximately 45% to 77% of elkhorn corals were impacted (NOAA 2018b). Survey data for impacts to elkhorn corals are not available for the United States Virgin Islands or Florida, though qualitative observations indicate that damage was also widespread but variable by site.

Throughout its range, there are some areas where populations are still somewhat abundant, such as Coral Gardens in Belize (Busch et al. 2016), Jardines de la Reina National Park in Cuba (Hernandez-Fernandez et al. 2019), Veracruz in Mexico (Larson et al. 2014), and St. John in the United States Virgin Islands (Muller et al. 2014). However, elkhorn coral appears to be continuing to decline in most locations surveyed, such as in Cuba (Caballero-Aragón et al. 2020), Venezuela (Croquer et al. 2016), and particularly in the northernmost portion of its range in Florida where declines since 2014 have been steeper than the previous decade (Williams et al. 2020). Most locations surveyed have patchy colonies with many colonies displaying partial mortality. There has been a decline in the number of reefs where elkhorn coral is present and little to no signs of sexual recruitment into the population. Depensatory effects such as genet incompatibility and spawning asynchrony hamper sexual reproduction. Events like hurricanes continue to heavily impact local populations. Genetic and genotypic diversity on a range-wide scale appear to remain high, though can be low at some local and regional scales. We conclude

there has been a significant decline of elkhorn coral throughout its range, as evidenced by the decreased frequency of occurrence and evidence of mortality, and that population abundance is likely to decrease in the future with increasing threats.

Status

The species has undergone substantial population decline and decreases in the extent of occurrence throughout its range due mostly to disease. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events. Elkhorn coral is highly susceptible to a number of threats, and cumulative effects of multiple threats are likely to exacerbate vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because elkhorn coral is limited to an area with high localized human impacts and predicted increasing threats. Elkhorn coral occurs in turbulent water on the back reef, fore reef, reef crest, and spur and groove zone in water ranging from 1 to 30 m in depth. This moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Elkhorn coral has low sexual recruitment rates, which exacerbates vulnerability to extinction due to decreased ability to recover from mortality events when all colonies at a site are extirpated. In contrast, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between rare events of sexual recruitment and increases its potential for local recovery from mortality events, thus moderating vulnerability to extinction. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. We anticipate that the population abundance is likely to decrease in the future with increasing threats.

Critical Habitat

In 2008, critical habitat was designated for threatened Caribbean acroporid corals (73 FR 72210; November 26, 2008). See Section 4.1.3 Elkhorn and Staghorn Corals - Designated Critical Habitat for details.

Recovery Goals

The 2015 Elkhorn Coral (*Acropora palmata*) and Staghorn Coral (*A. cervicornis*) Recovery Plan (NMFS 2015b) contains complete downlisting/delisting criteria for each of the two following recovery goals:

1. Ensure population viability

Specific criteria include: 1) Preserving Abundance; 2) Maintaining Genotypic Diversity; and 3) Properly Observing and Recording Recruitment Rates

2. Eliminate or sufficiently abate global, regional, and local threats

Specific criteria include: 1) Developing quantitative recovery criterion through research to identify, treat, and reduce outbreaks of coral disease; 2) Controlling the Local and Global Impacts of Rising Ocean Temperature and Acidification; 3) Reducing the Loss of Recruitment Habitat (if criterion 1, preserving abundance, is met then this objective is complete; 4) Reducing sources of nutrients, sediments, and contaminants; 5) Developing and adopting appropriate and effective regulatory mechanisms to abate threats; 6) Reducing impacts of natural and anthropogenic abrasion and breakage; and 7) Reducing impacts of predation.

4.2.21 Staghorn Coral

Staghorn coral was listed as threatened under the ESA in May 2006 (71 FR 26852). In December 2012, NMFS proposed changing its status from threatened to endangered (77 FR 73219). On September 10, 2014, NMFS determined that staghorn coral should remain listed as threatened (79 FR 53851).

Staghorn coral (*Acropora cervicornis*) has the same range as elkhorn coral, occurring throughout coastal areas in the Caribbean, Gulf of America, and southwestern Atlantic (Figure 43).

Staghorn coral is characterized by antler-like colonies with straight or slightly curved, cylindrical branches. The diameter of branches ranges from 0.25 – 5 cm (Lirman et al. 2010), and linear branch growth rates have been reported to range between 3 – 11.5 cm per year (Acropora Biological Review Team 2005). The species can exist as isolated branches, individual colonies up to about 1.5 m diameter, and thickets comprised of multiple colonies that are difficult to distinguish from one another (Acropora Biological Review Team 2005).

Life History

Staghorn coral naturally occurs on spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats (Goldberg 1973; Gilmore and Hall 1976; Cairns 1982; Davis 1982; Jaap 1984; Wheaton and Jaap 1988; Miller et al. 2008). Historically it grew in thickets in water ranging from approximately 5 – 20 m in depth; though it has rarely been found to approximately 60 m (Davis 1982; Jaap 1984; Schuhmacher and Zibrowius 1985; Wheaton and Jaap 1988; Jaap et al. 1989). At the northern extent of its range, it grows in deeper water, 16-30 m (Goldberg 1973). Historically, staghorn coral was one of the primary constructors of mid-depth 10-15 m reef terraces in the western Caribbean, including Jamaica, the Cayman Islands, Belize, and some reefs along the eastern Yucatan peninsula (Adey 1978). In the Florida Keys, staghorn coral occurs in various habitats but is most prevalent on patch reefs as opposed to their former abundance in deeper fore-reef habitats (Miller et al. 2008). There is no evidence of range constriction, though loss of staghorn coral at the reef level has occurred (Acropora Biological Review Team 2005).

Population Dynamics

Staghorn coral was historically one of the dominant species on most Caribbean reefs, forming large, single-species thickets and giving rise to the nominal distinct zone in classical descriptions of Caribbean reef morphology (Goreau 1959). Massive, Caribbean-wide mortality, apparently

primarily from white band disease (Aronson and Precht 2001), spread throughout the Caribbean in the mid-1970s to mid-1980s and precipitated widespread and radical changes in reef community structure (Brainard et al. 2011). In addition, continuing coral mortality from periodic acute events such as hurricanes, disease outbreaks, and mass bleaching events has added to the decline of staghorn coral (Brainard et al. 2011). In locations where quantitative data are available (Florida, Jamaica, U.S. Virgin Islands, Belize), there was a reduction of approximately 92 to greater than 97% between the 1970s and early 2000s (Acropora Biological Review Team 2005).

Information on staghorn coral status and populations dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations where data exist. Current information on abundance and population trends was most recently summarized in the 5-year review of the species (NMFS 2022c).

In surveys of the nearshore ridge complex from Hillsboro to Port Everglades conducted in 2011-2013 in southeast Florida, staghorn coral was present in 48% of the 1,956 sites (5000 m² each) (D'Antonio et al. 2016). Using the average colony size of 30 x 30 cm² (900 cm³), staghorn coral was abundant (>150 occurrences) at 11% of the sites, common (51-150 occurrences) at 11% of the sites, frequent (31-50 occurrences) at 5% of the sites, occasional (11-30 occurrences) at 8% of the sites, and rare (1-10 occurrences) at 13% of the sites. Staghorn coral was most frequently found at sites dominated by hardbottom (26%) and rubble (12%), and abundant populations tended to occur along the western edge of the ridge crest (D'Antonio et al. 2016).

Unpublished monitoring data from the Southeast Florida Coral Reef Evaluation and Monitoring Program (SECREMP) and the Coral Reef Evaluation and Monitoring Program (CREMP) in Florida show an overall decline in percent cover and live tissue area of staghorn coral in permanent monitoring stations in the Dry Tortugas, Florida Keys, and southeast Florida between 2014 and 2019 (NMFS 2022c). Declines were apparent at both the regional and state-wide level, though there was variability at individual sites. Across all 260 transects surveyed, the mean percent cover of staghorn coral decreased by an order of magnitude from 0.04% in 2014 to 0.003% in 2019. In contrast, at monotypic and special habitat sites in the Dry Tortugas, Florida, there was an increase in total live area of staghorn coral between 2014 and 2019.

Density and abundance have also generally declined in Florida. Unpublished CREMP and SECREMP data show mean density of staghorn coral in Florida decreased 4-fold from 2014 (0.017 colonies m⁻²) to 2019 (0.004 colonies m⁻²). However, patterns in mean density varied among regions. In the Dry Tortugas, the mean density of staghorn coral colonies was variable but remained relatively similar in 2014 and 2019. In contrast, the mean density of staghorn coral in the Florida Keys and southeast Florida decreased between 2014 and 2019. However, at monotypic and special habitat sites in the Dry Tortugas, density increased between 2014 and 2019 from 0.5 to 0.9 colonies m⁻². In a separate monitoring effort in southeast Florida conducted by Nova Southeastern University, abundance of staghorn coral colonies decreased between 2015 and 2020, particularly between 2017 and 2018, but the number of larger colony masses (area of coral where individual colonies are indistinguishable) remained stable (NMFS 2022c).

Coral demographics and population modeling have shown periods of stability but overall decline. A survey of two staghorn coral thickets over 8 years in southeast Florida showed temporal variability in mean percent cover but an overall loss of more than 50% (reduction from 17 to 3% at one site and 26 to 7% at the other) (Goergen et al. 2019). Disturbances including hurricanes, tropical storms, and disease events caused widespread and prolonged mortality; periods without disturbances allowed for recovery and growth. Fragmentation rates were not high enough to replace losses from disturbance events. The authors conclude that a more substantial amount of time between disturbance events than experienced during the study is necessary to allow for species growth and recovery and is unlikely with the existing pace of environmental changes.

Seasonal surveys of 5,515 staghorn coral colonies were conducted at 11 sites among three regions of Florida (Broward, middle Keys, and Dry Tortugas) from 2011 to 2015 (Goergen et al. 2020). There were differences in distribution among the regions. Sites in the northern region had cover from nearly 100% to sporadic colonies in low density on the periphery of the sites; the two other regions typically had sporadic clusters of low to moderate densities separated by tens of meters. Based on colony size, the proportion of colonies of reproductive size (>30 cm) was 60-80% in the northern region, 43-60% in the middle region, and 45-65% in the southern region. Overall, the mean colony maximum diameter was 44 cm with live tissue covering 72% of the colony. Recent mortality affected 17% of colonies surveyed with an average of 8% of tissue loss per colony. Disease caused the largest amount of tissue loss per colony in all regions. Mean diameter of colonies decreased from north to south, but the most southern region had on average a higher amount of live tissue per colony than the middle region. From the start to the end of the survey, mean colony diameter increased by 9% in the middle region and 22% in the southern region but decreased 1% in the northern region. However, changes in size class distribution were rarely observed.

In northeast Puerto Rico, a demographic model was developed by following 300 wild staghorn coral colonies (no thickets; mean colony height 19-23 cm) from 2011 to 2013 at two locations (Mercado-Molina et al. 2015). The model was used to perform a population viability analysis. Colony survival was between 88 and 89% during the first year; population growth decreased by 23 and 38% during the second year. There was a population decline ($\lambda < 1$) at both sites due to the lack of sexual recruitment, relatively low rates of colony fragmentation, and the combination of lower colony survival, little colony growth, and higher levels of colony shrinkage. The low probability of larger-sized colonies surviving and remaining in the largest size class was the demographic transition that contributed most to the temporal reduction in λ . The viability analysis predicted the populations would reach a quasi-extinction level of 25% of the initial population size in ≤ 16 years and become functionally extinct (10% of the initial population size) in ≤ 20 years. However, transplanting at least 50 colonies of small sized colonies (≤ 100 cm total linear length) per year was enough to keep the population growth rate positive.

Another analysis using the same two populations of staghorn coral in northeastern Puerto Rico as described above found that colony growth was more likely to occur when partial colony mortality was $\leq 20\%$ (Mercado-Molina et al. 2018). This was consistent among different size

classes. Analysis indicated that colonies with 20% or less partial mortality were between 6.5 and 28.7 times more likely to survive than colonies with higher partial mortality. In simulations, increasing the number of colonies with partial mortality by 25% during each time step caused the populations to reach a quasi-extinction level of 25% of the initial population size 3-4 years sooner.

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the United States Virgin Islands in 2017. Hurricane impacts included large, overturned and dislodged corals and extensive burial and breakage. At 153 survey locations in Puerto Rico, approximately 38% to 54% of staghorn corals were impacted (NOAA 2018b). In a post-hurricane survey of 57 sites in Florida, all of the staghorn coral colonies encountered were damaged by the hurricane (Florida Fish and Wildlife Conservation Commission, unpublished data). Survey data are not available for the United States Virgin Islands, though qualitative observations indicate that damage was also widespread but variable by site.

Overall, populations appear to consist mostly of isolated colonies or small groups of colonies compared to the vast thickets once prominent throughout its range. Thickets are a prominent feature at only a few known locations such as southeast Florida (D'Antonio et al. 2016) and Coral Gardens, Belize (Busch et al. 2016). Across the Caribbean, frequency of occurrence has decreased since the 1980s, and surveys indicate fewer sites with staghorn coral present in Florida, Cuba (González-Díaz et al. 2018; Hernandez-Fernandez et al. 2019), and Colombia (García-Urueña and Garzón-Machado 2020). Genetic and genotypic variation appear to remain high in most locations, though many populations maintain themselves through asexual fragmentation rather than new sexual recruitment. Population trends are stable or declining with variations on both temporal and spatial scales. In periods of stable environmental conditions, some populations are able to grow and recover from losses due to disturbances such as storms and disease events. However, with increasing frequency of these disturbances observed and expected in the future due to changing environmental conditions, the ability of these populations to maintain themselves will likely decline. Conservation efforts such as propagating corals in nurseries to use for population enhancement activities appear to be effective at increasing coral cover and keeping population growth positive with continuous input. These efforts are important at local scales to prevent local extirpation, but they likely will not be enough for species recovery without the abatement of global threats. Thus, we conclude that the species has undergone substantial population decline and decreases in the extent of occurrence throughout its range. We anticipate that population abundance is likely to decrease in the future with increasing threats.

Status

The species has undergone substantial population decline and decreases in the extent of occurrence throughout its range due mostly to disease. Staghorn coral is highly susceptible to a number of threats, and cumulative effects of multiple threats are likely to exacerbate vulnerability to extinction. There is evidence of synergistic effects of threats for this species. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because staghorn coral is limited to areas with high, localized human

impacts and predicted increasing threats. Staghorn coral commonly occurs in water ranging from 5 to 15 m in depth, though it has been rarely found to 60 m in depth. It occurs in spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats. This habitat heterogeneity moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef and hard bottom environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Staghorn coral has low sexual recruitment rates, which exacerbates vulnerability to extinction due to decreased ability to recover from mortality events when all colonies at a site are extirpated. In contrast, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between stress events when environmental conditions are favorable. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate the species' vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, we anticipate that the population abundance is likely to decrease in the future with increasing threats.

Critical Habitat

In 2008, critical habitat was designated for threatened Caribbean acroporid corals (73 FR 72210; November 26, 2008). In 2008, critical habitat was designated for threatened Caribbean acroporid corals (73 FR 72210; November 26, 2008). See Section 4.1.3 Elkhorn and Staghorn Corals - Designated Critical Habitat for details.

Recovery Goals

The recovery goals for elkhorn and staghorn corals were described in the 2015 Elkhorn Coral (*Acropora palmata*) and Staghorn Coral (*A. cervicornis*) Recovery Plan (NMFS 2015b) and detailed in the elkhorn coral status of the species section above. Two recovery goals were identified for Atlantic acroporid corals:

1. Ensure population viability;
2. Eliminate or sufficiently abate global, regional, and local threats

See Section 4.2.1 Elkhorn Coral above for specific criteria.

4.2.22 Pillar Coral

On September 10, 2014, NMFS listed pillar star coral as threatened (79 FR 53851). On December 17, 2024 NMFS published a rule changing the status of pillar coral from threatened to endangered (89 FR 101993).

Pillar corals form tubular columns on top of encrusted foundations. Colonies are generally grey-brown in color and may reach approximately 3 m in height. Polyps' tentacles remain extended during the day, giving columns a furry appearance. Pillar coral is present (Figure 44) in the western Atlantic Ocean and throughout the greater Caribbean Sea, though is absent from the

southwest Gulf of America (Tunnell 1988). Brainard et al. (2011) identified a single known colony in Bermuda that is in poor condition. There is fossil evidence of the presence of the species off Panama less than 1,000 years ago, but it has been reported as absent today (Florida Fish and Wildlife Conservation Commission 2013). Pillar coral inhabits most reef environments in water depths ranging from approximately 3-75 ft (1-25 m), but it is most common in water between approximately 15-45 ft (5-15 m) deep (Goreau and Wells 1967; Cairns 1982; Acosta and Acevedo 2006).

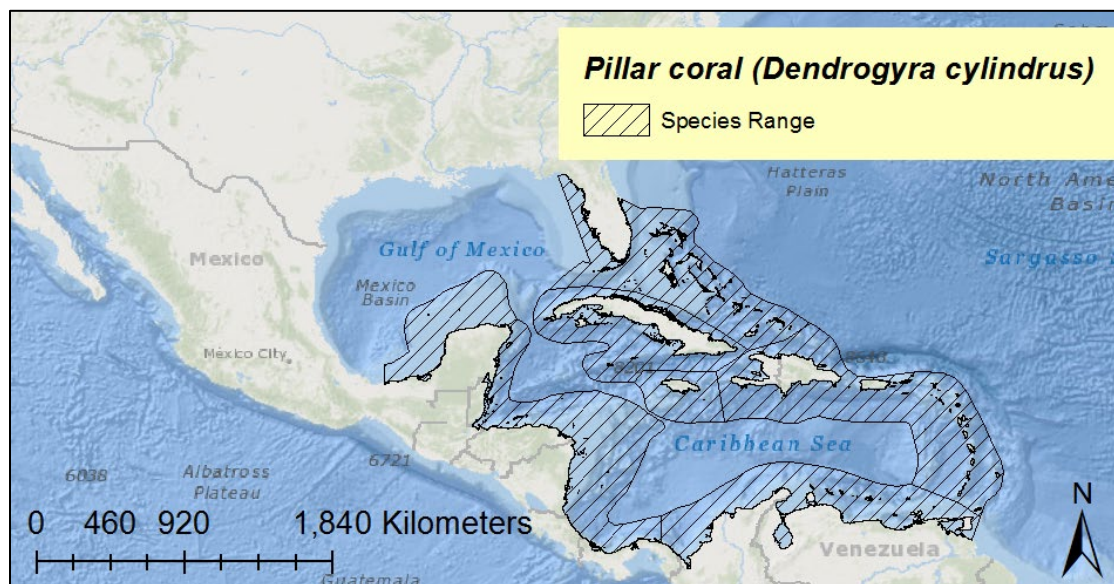


Figure 44. Range Map for Pillar Coral

Life history

Pillar coral has been considered a gonochoric, broadcast spawning¹⁶ species, but cases of hermaphroditism have been observed (Kabay 2016; Neely et al. 2018; Neely et al. 2020), indicating flexibility in reproductive mode. Pillar coral has relatively low annual egg production for its size. Sexual recruitment of this species is low, and there have been no reports of juvenile colonies in the Caribbean. Spawning has been observed to occur several nights after the full moon of August but can occur a month earlier or later depending on the geographic location (Szmant 1986; Neely et al. 2013; Marhaver et al. 2015; Neely et al. 2020). Pillar coral can also reproduce asexually by fragmentation following storms or other physical disturbance, but it is uncertain how much storm generated fragmentation contributes to asexually produced offspring. The average growth rate is about 0.3 in (0.8 cm) per year (Hughes 1987; Acosta and Acevedo 2006).

¹⁶ Parents only contain one gamete type (egg or sperm), which are released into the water column for fertilization by another parent's gametes.

Population Dynamics

Pillar coral has been described as a naturally rare species. It is found as scattered isolated colonies but occasionally in aggregations. Information on pillar coral status and populations dynamics is spotty throughout its range. Comprehensive and systematic census and monitoring has not been conducted outside of Florida. Thus, the status and populations dynamics must be inferred from the few locations where data exist. Current information on abundance and population trends was most recently summarized in the 5-year review of the species (NMFS 2022c).

New scientific and commercial data indicates there have been declines in the abundance and distribution in multiple locations with the most severe declines in the northern portions of its range (NMFS 2022b). In locations where stony coral tissue loss disease (SCTLD) has been observed, pillar coral has experienced high rates of disease, fast disease progression, and high mortality from SCTLD. As a result of SCTLD, pillar coral has disappeared from individual sites in Florida, Mexico, and the USVI and is nearly extirpated in Florida. In addition, no observed recruitment has been reported in the wild and reductions in population size and local extinctions with inhibit the species' ability to replenish populations through asexual and sexual reproduction. In Old Providence and St. Catalina Islands, which host more than 90% of the pillar coral population in Colombia, surveys of pillar coral in 2002 and 2012 revealed that average colony and fragment size were reduced and the number of colonies and overall amount of partial mortality was increased over the 10-year span (Bernal-Sotelo et al. 2019). There were consecutive thermal bleaching events in 2014 and 2015, as well as ongoing and emerging disease events, which affected the monitored colonies. Recovery from bleaching was calculated to take 11 years (in the absence of additional severe stressors) based on colony growth rates observed after bleaching, but before disease (Neely et al. 2021a). Modeling of the species was conducted to examine the effects of thermally-induced bleaching stress events. Assuming two stress events per decade until 2042 when thermal stress events are predicted to become annual, local extinction of pillar coral in Florida was predicted to occur in between 2039 and 2066 (Chan et al. 2019). These modeling predictions did not account for disease, which was observed to cause near extirpation from Florida much sooner than the model predicted dates for local extinction (Neely et al. 2021a).

Between 2013 and 2020, pillar coral colonies in Florida were monitored, with baseline surveys revealing a total of 542 colonies (533 alive), average tissue mortality of 30%, and recent low levels of mortality (2.2%) in 22% of colonies (Neely et al. 2021a). During the monitoring period, there were chronic stressors that occurred on about 1% of colonies and caused minor damage (on average less than 1% tissue loss), including damselfish gardens/nests, predation by the corallivorous snail (*Coralliophila abbreviata*), competition with other benthic organisms, and abrasion and burial. Acute stressors, including the 2014 and 2015 bleaching events, ongoing outbreaks of white plague and black band disease, and the outbreak of SCTLD, resulted in extremely high mortality (Lewis, 2018; Lewis et al. 2017; Neely et al. 2021a). By the end of the monitoring period in 2020, there had been a 94% loss of coral tissue and 93% loss of colonies, due primarily to disease. The species experienced severe loss of coral tissues and colonies from

2013 to 2020 and is now considered functionally extinct along the Florida reef tract (Neely et al. 2021a, Figure 45).

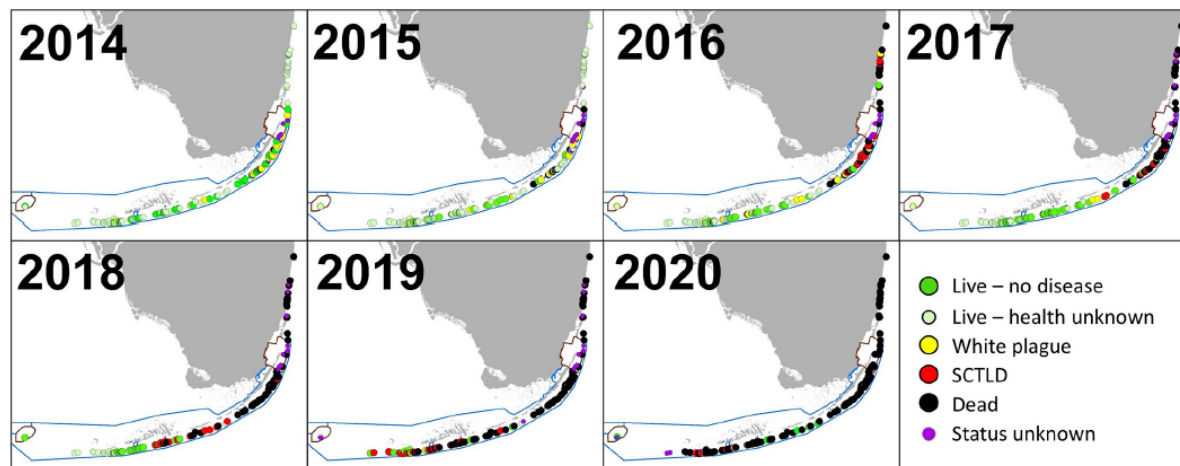


Figure 45. Status of Known Pillar Coral Colonies in Florida between 2014 and 2020 (Neely et al. 2021)

Pillar coral colonies infected with SCTLD have been reported in the Bahamas (Dahlgren et al. 2021), and local extirpations have been reported in Mexico (Alvarez-Filip et al. 2019; Estrada-Saldivar et al. 2021) and in the United States Virgin Islands (Brandt et al. 2021). Although quantitative population trend data are only available from Florida and Columbia, we assume the species is in decline throughout most of its range based on the evidence from these regions, which represent the northern and southwestern portions of its range, and the widespread evidence of severe disease (NMFS 2022b).

The monitoring of Florida pillar coral colonies from 2013 and 2020 included a total of 819 colonies of an assumed 190 genotypes based on genetic testing or colony distances from each other (Neely et al. 2021a). Distances between genotypes on average was about 0.6 mi (1 km), ranging from 8.2 ft to 4.1 mi (2.5 m to 6.6 km). Half of the colonies represented clones of only five genotypes, with 62% of the genotypes represented by a single colony. Asexual reproduction accounted for 77% of the colonies. At the end of 2020, there had been an 86% loss of genotypes, with only 25 known genotypes remaining. Half of the remaining genotypes declined to less than 2% live tissue and the other half were actively experiencing rapid tissue loss due to SCTLD. Only two genotypes remained unaffected at the end of 2020, located in the Dry Tortugas where SCTLD had not yet reached at the time of the study, but has now.

Status

Pillar coral is susceptible to a number of threats, and there is evidence of population declines in some locations and severe declines in Florida. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because pillar coral is limited to an area with high, localized human impacts and predicted increasing

threats. Pillar coral inhabits most reef environments in water depths ranging from 3-82 ft (1-25 m), but is naturally rare. It is a broadcast spawner with observed low sexual recruitment. Its low abundance, combined with its geographic location, exacerbates vulnerability to extinction. This is because increasingly severe conditions within the species' range are likely to affect a high proportion of its population at any given point in time. Also, low sexual recruitment, combined with its broadcast spawning reproduction mode and low density, is likely to inhibit recovery potential from mortality events, further exacerbating its vulnerability to extinction. We anticipate that pillar coral is likely to decrease in abundance in the future with increasing threats.

Information on pillar coral is most extensive for Florida. Pillar coral ranked as the least abundant to third least abundant coral species in stratified random surveys of the Florida Keys between 2005 and 2009 and was not encountered in surveys in 2012 (Miller et al. 2013). Pillar coral was seen only on the ridge complex and mid-channel reefs at densities of approximately 1 and 0.1 colonies per 10 m², respectively, between 2005 and 2010 in surveys from West Palm Beach to the Dry Tortugas (Burman et al. 2012). In surveys conducted between 1999 and 2016 from Palm Beach to the Dry Tortugas, pillar coral was present at 2% of sites surveyed and ranged in density from 0 to 0.4 colonies per m² with an average density of 0.004 colonies per 10 m² (NOAA, unpublished data). In 2014, there were 714 known colonies of pillar coral along the Florida reef tract from southeast Florida to the Dry Tortugas. By 2017, many of these colonies had suffered tissue loss, and over half (57%) suffered complete mortality due to disease, most likely associated with multiple years of warmer than normal temperatures (K. Neely, Nova Southeastern University, and C. Lewis, Florida International University, unpublished data). The majority of these colonies were lost from the northern portion of the reef tract (Figure 46).

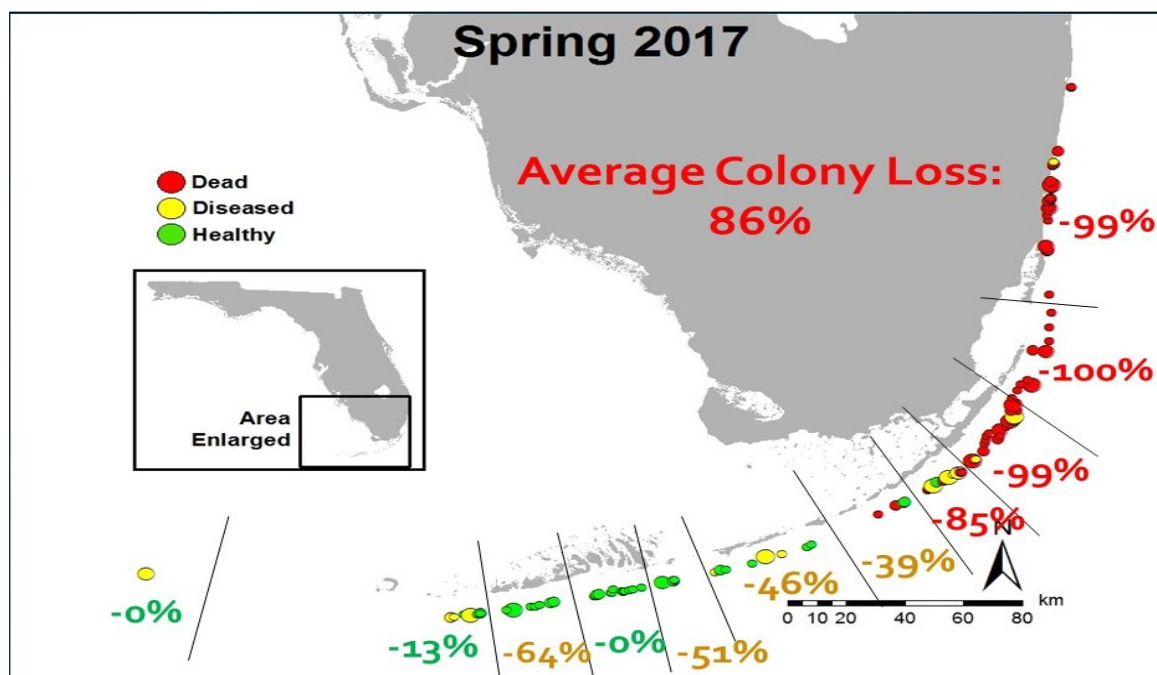


Figure 46. Condition of Known Pillar Coral Colonies in Florida between 2014 and 2017 (Figure courtesy of K. Neely, Nova Southeastern University, and C. Lewis, Florida International University)

Pillar coral is susceptible to ocean warming, disease, ocean acidification, sedimentation, and nutrients, and the trophic effects of fishing. Pillar coral appears to have some susceptibility to ocean warming, though there are conflicting characterizations of the susceptibility of pillar coral to bleaching with some locations experiencing bleaching of up to 100% of pillar coral colonies and others experiencing lesser percentages during the same event (e.g., 36%; (Oxenford et al. 2008; Bruckner and Hill 2009). Reports of low mortality after less severe bleaching indicate potential resilience, though mortality information is absent from locations that reported high bleaching frequency. Pillar coral is also sensitive to cold temperatures, with cold shock producing severe bleaching and up to 100% mortality in some locations (Muscatine et al. 1991; Kemp et al. 2011).

Pillar coral is susceptible to black band disease and white plague, though impacts from white plague are likely more extensive because of rapid progression rates (Brainard et al. 2011). Disease appears to be present in about 3 to 4% of pillar coral populations in locations surveyed (Acosta and Acevedo 2006; Ward et al. 2006). Pillar coral is highly susceptible to SCTLD and is often one of the first species to become infected (Florida Coral Disease Response Research & Epidemiology Team 2018). SCTLD appears to be transmissible through both water and direct contact, and sediment can act as a vector (Aeby et al. 2019; Studivan et al. 2022). SCTLD does not appear to be seasonal like many other coral diseases and surveys have shown that pillar coral exhibits high disease prevalence and colony mortality (Brandt et al. 2021; Alvarez-Filip et al. 2019). Coral colonies infected with SCTLD have been effectively treated to stop progression of the disease, but not to prevent new lesions from forming (Neely et al., 2020b; Shilling et al., 2021; Walker et al., 2021). A rescue effort was undertaken to collect fragments of live colonies and bring them under human care in both land-based and ocean-based nurseries for preservation and to aid in propagation and future restoration (Kabay, 2016; Neely et al., 2021b; O'Neil et al., 2021). The species has successfully reproduced in captivity and gametes from wild colonies have successfully transferred to captivity (Marhaver et al., 2015; Villalpando et al., 2021; O'Neil et al., 2021).

Critical Habitat

Critical habitat was designated in 2023 for Caribbean coral species (88 FR 54026). See Section 4.1.3 Atlantic/Caribbean Corals - Designated Critical Habitat for details.

Recovery Goals

No final recovery plans currently exists for pillar coral, however a recovery outline was published in 2015. The following short and long-term recovery goals are listed in the document:

- Short Term Goals:
 - Increase understanding of population dynamics, population distribution, abundance, trends, and structure through research, monitoring, and modeling
 - Through research, increase understanding of genetic and environmental factors that lead to variability of bleaching and disease susceptibility

- Decrease locally manageable stress and mortality sources (e.g., acute sedimentation, nutrients, contaminants, and over-fishing).
- Prioritize implementation of actions in the recovery plan for elkhorn and staghorn corals that will benefit *D. cylindrus*, *M. ferox*, and *Orbicella* spp.
- Long Term Goals:
 - Cultivate and implement U.S. and international measures to reduce atmospheric carbon dioxide concentrations to curb warming and acidification impacts and possibly disease threats.
 - Implement ecosystem-level actions to improve habitat quality and restore keystone species and functional processes to maintain adult colonies and promote successful natural recruitment.

4.2.23 Rough Cactus Coral

On September 10, 2014, NMFS listed rough cactus coral as threatened (79 FR 53851). Rough cactus coral forms a thin, encrusting plate that is weakly attached to the substrate. Rough cactus coral is taxonomically distinct (i.e., separate species), though difficult to distinguish in the field from other *Mycetophyllia* species. Maximum colony size is 20 in (50 cm) in diameter. Rough cactus coral occurs in the western Atlantic Ocean and throughout the wider Caribbean Sea. It has not been reported in the Flower Garden Banks (Gulf of America) or in Bermuda. It inhabits reef environments in water depths of 16-295 ft (5-90 m), including shallow and mesophotic habitats (e.g., > 100 ft [30 m]).

Rough cactus coral (*Mycetophyllia ferox*) occurs in the western Atlantic Ocean and throughout the wider Caribbean Sea (Figure 47).

Life History

Rough cactus coral is a hermaphroditic brooding¹⁷ species. Colony size at first reproduction is greater than 15 in² (100 cm²). Recruitment of rough cactus coral appears to be very low, even in studies from the 1970s. Rough cactus coral has a lower fecundity compared to other species in its genus (Morales Tirado 2006). Over a 10-year period, no colonies of rough cactus coral were observed to recruit to an anchor-damaged site in the U.S. Virgin Islands, although adults were observed on the adjacent reef (Rogers and Garrison 2001). No other life history information appears to exist for rough cactus coral.

Population Dynamics

Information on rough cactus coral status and populations dynamics is sparse throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations where data exist.

¹⁷ Simultaneously containing both sperm and eggs; eggs are fertilized within the parent colony and develop into larvae before release.

Current information on abundance and population trends was most recently summarized in the 5-year review of the species (NMFS 2022c).

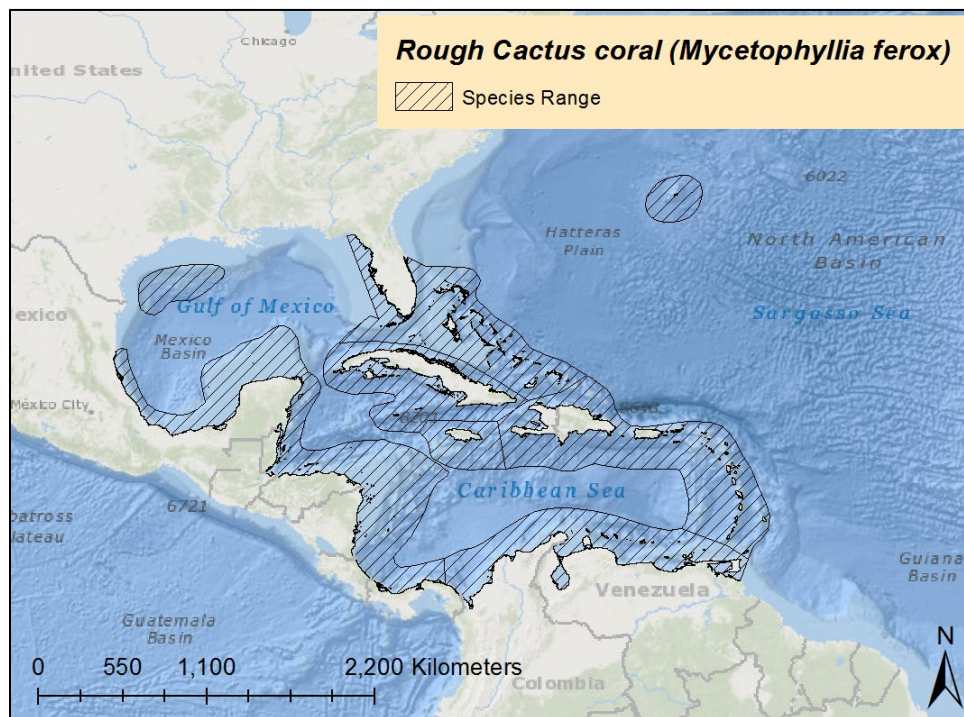


Figure 47. Range Map for Rough Cactus Coral

Rough cactus corals are uncommon and typically occur at an average density of <0.001 to 0.02 colonies per m^2 . In benthic surveys conducted in the United States Virgin Islands between 2002 and 2018, rough cactus corals were encountered in less than half of the survey years, and density was ≤ 0.001 colonies per m^2 at the 1% to 2% of sites where they occurred (NOAA, unpublished data). Unpublished data from stratified random surveys (different sites surveyed each year) indicate that the percentage of sites in the United States Virgin Islands and Puerto Rico with *M. ferox* present ranged from 0 to 2.5% and declined between 2014 and 2019 (NMFS 2022c). Rough cactus corals were present at 8% of sites surveyed in Puerto Rico in 2008, but in surveys conducted between 2010 and 2018, they were found at 1% to 4% of surveyed sites at an average density of <0.001 to 0.004 colonies per m^2 (NOAA, unpublished data). Rough cactus corals were encountered in 2% to 10% of sites surveyed in Florida between 1999 and 2006, but in surveys between 2007 and 2017, they were only encountered in three survey years and at only 1% of sites at an average density of <0.001 colonies per m^2 (NOAA, unpublished data). Density of rough cactus coral in southeast Florida and the Florida Keys was approximately 0.8 colonies per approximately 100 ft^2 (10 m^2) between 2005 and 2007 (Wagner et al. 2010). In a survey of 97 stations in the Florida Keys, rough cactus coral declined in occurrence from 20 stations in 1996 to 4 stations in 2009 (Brainard et al. 2011). At 21 stations in the Dry Tortugas, rough cactus coral declined in occurrence from 8 stations in 2004 to 3 stations in 2009 (Brainard et al. 2011). Unpublished data from permanent monitoring transects in Florida show a decline in rough cactus coral percent cover, live tissue area, and density between 2014 and 2019 (NMFS 2022c). These

patterns were similar in both the Dry Tortugas and the Florida Keys (no colonies were observed in the southeast Florida transects). Taken together, these data indicate that the species has declined in Florida and potentially also in Puerto Rico and the United States Virgin Islands over the past one to two decades.

A recent coral disease event has greatly affected coral populations in Florida. This unprecedented, multi-year disease event, which began in 2014, swept through Florida and caused massive mortality across the reef tract. The effects of this widespread disease have been severe, causing mortality of millions of coral colonies across several species, including *Mycetophyllia* species. At study sites in southeast Florida, prevalence of disease was recorded at 67% of all coral colonies and 81% of colonies of those species susceptible to the disease (Precht et al. 2016). No species-specific information is available for the effects of disease on rough cactus coral, but in a survey of 134 sites conducted between October 2017 and April 2018, 9% of *Mycetophyllia* species were affected (Neely 2018). This disease prevalence is a snapshot in time and does not represent the total proportion of *Mycetophyllia* species affected by the disease outbreak.

Average benthic cover of rough cactus coral in the Red Hind Marine Conservation District off St. Thomas, U.S. Virgin Islands, which includes mesophotic coral reefs, was 0.003% in 2007, accounting for 0.02% of coral cover, and ranking 19 out of 21 coral species (Nemeth et al. 2008; Smith et al. 2010). In the U.S. Virgin Islands between 2001 and 2012, rough cactus coral appeared in 12 of 33 survey sites and accounted for 0.01% of the colonized bottom and 0.07% of the coral cover, ranking as 13th most common coral on the reef (Smith 2013).

Rough cactus coral has been reported to occur on a low percentage of surveyed reefs and is one of the least common coral species observed. On reefs where rough cactus coral is found, it generally occurs at abundances of less than 1 colony per approximately 100 ft² (10 m²) and cover of less than 0.1%. Low encounter rate and percent cover coupled with the tendency to include *Mycetophyllia* spp. at the genus level make it difficult to discern population trends of rough cactus coral from monitoring data. However, reported losses of rough cactus coral from monitoring stations in the Florida Keys and Dry Tortugas (63-80% loss) and decreased encounter frequency in Puerto Rico and the United States Virgin Islands indicate the population has declined.

Status

Rough cactus coral has declined due to disease in at least a portion of its range and has low recruitment, which limits its capacity for recovery from mortality events and exacerbates vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because rough cactus coral is limited to an area with high, localized human impacts and predicted increasing threats. Its depth range of 5 to 90 m moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower temperatures than surface waters. Acidification is predicted to accelerate most in deeper and cooler waters than those in which the species

occurs. Its habitat includes shallow and mesophotic reefs which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Rough cactus coral is usually uncommon to rare throughout its range. Its abundance, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, we anticipate that the population abundance is likely to decrease in the future with increasing threats.

Critical Habitat

Critical habitat was designated in 2023 for Caribbean coral species (88 FR 54026, August 9, 2023). See Section 4.1.3 Atlantic/Caribbean Corals - Designated Critical Habitat for details.

4.2.24 Lobed Star, Mountainous Star, and Boulder Star Coral

Lobed, mountainous, and boulder star coral (*Orbicella annularis*, *Orbicella faveolata*, and *Orbicella franksi*) occur in the western Atlantic and greater Caribbean as well as the Flower Garden Banks. Lobed and mountainous star coral may be absent from Bermuda (Figure 48).

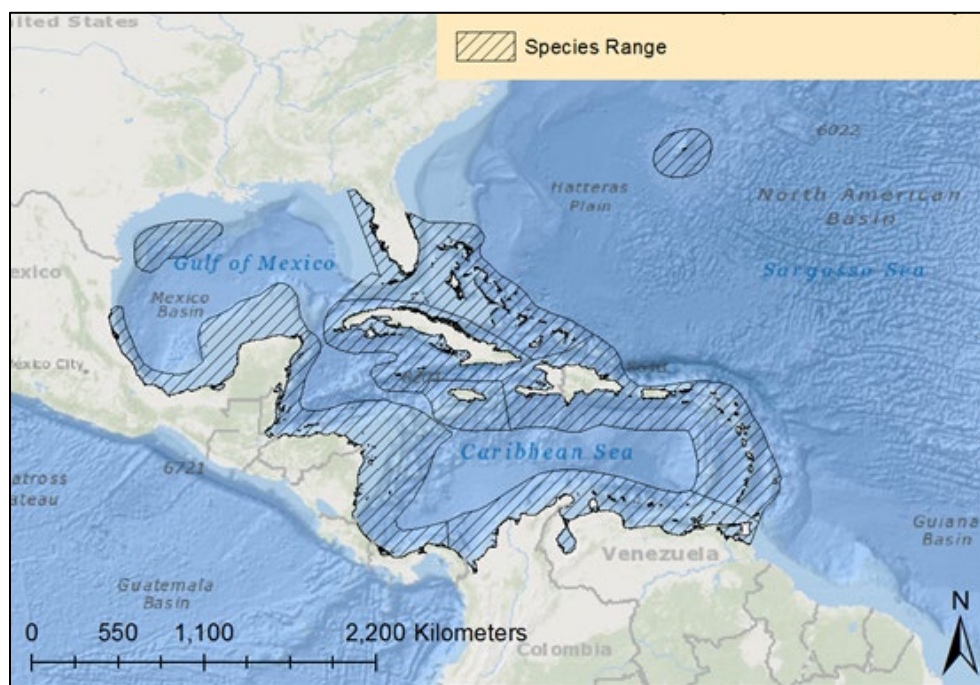


Figure 48. Range Map for Lobed, Mountainous, and Boulder Star Corals

On September 10, 2014, NMFS listed mountainous star coral as threatened (79 FR 53851). Lobed star coral (*Orbicella annularis*), mountainous star coral (*Orbicella faveolata*), and boulder star coral (*Orbicella franksi*) are the three species in the *Orbicella annularis* (star coral) complex. These three species were formerly in the genus *Montastraea* but have been reclassified

to the genus *Orbicella* (Budd et al. 2012). The star coral species complex was historically one of the primary reef framework builders throughout the wider Caribbean. The complex was considered a highly plastic, single species –*Montastraea annularis*– with growth forms ranging from columns, to massive boulders, to plates. In the early 1990s, Weil and Knowlton (1994) suggested the partitioning of these growth forms into separate species, resurrecting the previously described taxa, *Montastraea* (now *Orbicella*) *faveolata*, and *Montastraea* (now *Orbicella*) *franksi*. These three species were differentiated on the basis of morphology, depth range, ecology, and behavior (Weil and Knowlton 1994). Subsequent reproductive and genetic studies have supported the partitioning of the *annularis* complex into three species.

Some studies report on the species complex rather than individual species because visual distinction can be difficult where colony morphology cannot be discerned (e.g., small colonies or photographic methods). Information from these studies is reported for the species complex. Species-specific information is reported when available. Information about *Orbicella annularis* published prior to 1994 will be attributed to the species complex, since it is dated prior to the split of *Orbicella annularis* into three separate species.

Life History

The star coral species complex has growth rates ranging from 0.02-0.5 in (0.06-1.2 cm) per year and averaging approximately 0.3 in (1 cm) linear growth per year.

The reported growth rate of lobed star coral is 0.4 to 1.2 cm per year (Tomascik 1990; Cruz-Piñón et al. 2003). Mountainous star coral's growth rate is intermediate between the other star coral species complex (Szmant et al. 1997). Boulder star coral is reported to be the slowest growing of the three species in the complex (Brainard et al. 2011). The star corals grow slower in deeper water and in more turbid waters. Lobed star coral colonies grow in columns that exhibit rapid and regular upward growth. In contrast to the other two star coral species, margins on the sides of columns are typically dead. Live colony surfaces usually lack ridges or bumps. The reported growth rate of lobed star coral is 0.16-0.47 in (0.4-1.2 cm) per year (Tomascik 1990; Cruz-Piñón et al. 2003).

Lobed star coral colonies grow in columns that exhibit rapid and regular upward growth. In contrast to the other two star coral species, margins on the sides of columns are typically dead. Live colony surfaces usually lack ridges or bumps. Mountainous star coral grows in heads or sheets, the surface of which may be smooth or have keels or bumps. The skeleton is much less dense than in the other 2 star coral species. Colony diameters can reach up to 33 ft (10 m) with heights of 13-16 ft (4-5 m). Boulder star coral is distinguished by large, unevenly arrayed polyps that give the colony its characteristic irregular surface. Colony form is variable, and the skeleton is dense with poorly developed annual bands. Colony diameter can reach up to 5 m with a height of up to 2 m.

All three species of the star coral species complex are hermaphroditic broadcast spawners,¹⁸ and spawning is concentrated on 6-8 nights following the full moon in late August, September, or early October, depending on location and timing of the full moon. All three species are largely self-incompatible (Knowlton et al. 1997; Szmant et al. 1997). Fertilization success measured in the field was generally below 15% for all 3 species. Minimum size at reproduction for the star coral species complex is 12 in² (83 cm²).

Lobed star coral is reported to have slightly smaller egg size and potentially smaller size/age at first reproduction than the other two species of the *Orbicella* genus. Minimum size at reproduction for the star coral species complex is 12 in² (83 cm²).

Successful recruitment by the star coral species complex has seemingly always been rare. Only a single recruit of *Orbicella* was observed over 18 years of intensive observation of 130 ft² (12 m²) of reef in Discovery Bay, Jamaica. Many other studies throughout the Caribbean also report negligible to absent recruitment of the species complex.

Life history characteristics of mountainous star coral is considered intermediate between lobed star coral and boulder star coral especially regarding growth rates, tissue regeneration, and egg size. Spatial distribution may affect fecundity on the reef, with deeper colonies of mountainous star coral being less fecund due to greater polyp spacing. Reported growth rates of mountainous star coral range between 0.12-0.64 in (0.3-1.6 cm) per year (Tomascik 1990; Cruz-Piñón et al. 2003; Villinski 2003; Waddell 2005). Graham and van Woesik (2013) report that 44% of small colonies of mountainous star coral in Puerto Morelos, Mexico that resulted from partial colony mortality produced eggs at sizes smaller than those typically characterized as being mature. The number of eggs produced per unit area of smaller fragments was significantly less than in larger size classes. Szmant and Miller (2005) reported low post-settlement survivorship for mountainous star coral transplanted to the field with only 3-15% remaining alive after 30 days. Post-settlement survivorship was much lower than the 29% observed for elkhorn coral after seven months (Szmant and Miller 2005).

Population Dynamics

Information on star coral complex status and population dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations where data exist. Current information on abundance and population trends was most recently summarized in the 5-year review of the species (NMFS 2022c).

Successful recruitment by the star coral complex species has seemingly always been rare. Only a single recruit of *Orbicella* was observed over 18 years of intensive observation of 130 ft² (12 m²)

¹⁸ Simultaneously containing both sperm and eggs, which are released into the water column for fertilization.

of reef in Discovery Bay, Jamaica. Many other studies throughout the Caribbean also report negligible to absent recruitment of the species complex.

In addition to low recruitment rates, species in the star coral complex have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the star coral species complex in the past (Bruckner 2012). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, the buffering capacity of this life history strategy has likely been reduced by recent population declines and partial mortality, particularly in large colonies.

Boulder Star Coral

Boulder star coral is distributed in the western Atlantic Ocean and throughout the Caribbean Sea including in the Bahamas, Bermuda, and FGBNMS. Boulder star coral tends to have a deeper distribution than the other two species in the *Orbicella* species complex. It occupies most reef environments and has been reported from water depths ranging from approximately 16-165 ft (5-50 m), with the species complex reported to 250 ft (90 m). *Orbicella* species are a common, often dominant, component of Caribbean mesophotic reefs (e.g., >100 ft; 30 m), suggesting the potential for deep refugia for boulder star coral.

Boulder star coral is less frequently encountered than the other two species in the species complex. In a survey of 52 stations in St. Croix in 2007 and 52 stations in St. Thomas and St. John in 2009, boulder star corals was observed in 12% of stations in St. Croix and 50% in St. Thomas and St. John (Fisher et al. 2014). This species was present in a lower proportion of stations than either lobed star coral (31-65% of stations) or boulder star corals (60-73% of stations). In Cuba, surveys were conducted in 37 sites (9-15 m depth) interspersed among the seven coral reef systems between 2010 and 2016 (González-Díaz et al. 2018). *Orbicella* spp. were uncommon to rare, suggesting substantial losses prior to these surveys. However, *Orbicella* spp. were moderately common at Península Ancón and Jardines de la Reina (González-Díaz et al. 2018).

In addition to low recruitment rates, boulder star corals have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the star coral species complex in the past (Bruckner 2012). Large colonies in the species complex maintain the population until conditions favorable for

recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, the buffering capacity of this life history strategy has likely been reduced by recent population declines and partial mortality, particularly in large colonies.

Unpublished monitoring data from long-term benthic monitoring programs show that between 2014 and 2019, the amount of live tissue of boulder star corals was relatively stable in Florida, though regional trends indicated an overall decline in the Florida Keys and an increase in the Dry Tortugas (southeast Florida close to 0). Average density in Florida was also relatively stable when averaged across all transects and ranged from a low of 0.04 colonies m^{-2} in 2015 to a high of 0.07 colonies m^{-2} in 2018. Density in the Dry Tortugas was higher than in the Florida Keys and southeast Florida and increased between 2014 and 2019 (NMFS 2022c).

Unpublished data from the United States Virgin Islands long-term monitoring program show cover of boulder star corals was relatively stable between 2014 and 2020, hovering around 4.5% to 5.5%. If these sites are evaluated by depth classes, most depths show stable or increasing cover of boulder star corals between 2014 and 2017 and then a decrease in 2018 that either stabilized or continued to decline. The exception was sites 21-30 m in depth that showed a decline in 2019 but then an increase in 2020 (though note that not all sites were surveyed in 2020) (NMFS 2022c).

Unpublished monitoring data from randomly surveyed sites (different sites surveyed each year) include colony size and partial mortality. Between 2014 and 2020, mean colony diameter appeared relatively stable at about 30 cm in Puerto Rico and the United States Virgin Islands while the Dry Tortugas had stable mean colony diameter slightly higher at approximately 40 cm. Southeast Florida and the Florida Keys exhibited more variability in mean colony diameter among survey years, but in the most recent survey in 2018, mean colony diameter was slightly less than 40 cm in the Florida Keys and slightly over 60 cm in southeast Florida. Mean partial mortality of boulder star corals colonies was about 15-30% in the Dry Tortugas, United States Virgin Islands, and Puerto Rico. In the Florida Keys and southeast Florida, partial colony mortality was more variable with the average ranging from about 15-50% in the Florida Keys and from about 20-40% in southeast Florida (NMFS 2022c).

In randomly sampled sites (different sites surveyed each year), the presence of boulder star corals was variable from year to year in Florida, the United States Virgin Islands, and Puerto Rico, but no regions showed any overall patterns of decreased presence between 2014 and 2019 (NMFS 2022c). Boulder star corals was present at approximately 30-50% of sites in the Dry Tortugas and United States Virgin Islands, 5-30% of sites in the Florida Keys, 15-20% in Puerto Rico, and 0-5% in southeast Florida (NMFS 2022c).

Stony coral tissue loss disease (SCTLD) has greatly impacted boulder star coral populations in Florida and the U.S. Caribbean. First identified in Florida in 2014, this unprecedented disease has since spread throughout most of the Caribbean. The effects of SCTLD have been severe, causing mortality of millions of coral colonies across multiple species, including boulder star coral.

Because almost all colonies succumb completely to SCTLD, prevalence is a good indicator of mortality rate (Precht et al. 2016). At study sites in southeast Florida, prevalence of disease was recorded at 67% of all coral colonies and 81% of colonies of those species susceptible to the disease (Precht et al. 2016).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the United States Virgin Islands in 2017. Hurricane impacts included large, overturned and dislodged coral heads and extensive burial and breakage. At 153 survey locations in Puerto Rico, boulder star corals was present in about half of the sites visited, and approximately 10-14% of boulder star corals were impacted (NOAA 2018b). In Florida, approximately 23% of boulder star corals surveyed at 57 sites were impacted (Florida Fish and Wildlife Conservation Commission, unpublished data). Survey data are not available for the United States Virgin Islands, though qualitative observations indicate that damage was also widespread but variable by site.

Overall, abundance of boulder star coral appears stable in some locations such as the Dry Tortugas and United States Virgin Islands and has declined in others such as the Florida Keys. The buffering capacity of its life history strategy that allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We anticipate that population abundance is likely to decrease in the future with increasing threats.

Lobed Star Coral

Lobed star coral is reported from most reef environments within the Caribbean (except for Bermuda) in depths of approximately 1.5-66 ft (0.5-20 m). The star coral species complex is a common, often dominant component of Caribbean mesophotic (e.g., >100 ft; 30 m) reefs, suggesting the potential for deep refuge across a broader depth range, but lobed star coral is generally described with a shallower distribution.

Asexual fission and partial mortality can lead to multiple clones of the same colony. The percentage of unique individuals is variable by location and is reported to range between 18 and 86% (thus, 14-82% are clones). Colonies in areas with higher disturbance from hurricanes tend to have more clonality. Genetic data indicate that there is some population structure in the eastern, central, and western Caribbean with population connectivity within but not across areas. Although lobed star coral is still abundant, it may exhibit high clonality in some locations, meaning that there may be low genetic diversity.

Unpublished monitoring data of permanent monitoring sites were summarized in the five-year review (NMFS 2022c). Live coral tissue area in Florida decreased substantially between 2014 and 2015 and then continued to gradually decline until 2019. This declining trend was visible in both southeast Florida and the Florida Keys as well as in monospecific/special habitat sites in the Dry Tortugas. In long-term monitoring sites in the United States Virgin Islands, percent cover of lobed star coral decreased slightly overall between 2015 and 2020 with shallower sites (<20 m)

showing declines and sites 21-30 m in depth increasing in cover. The percentage of sites where lobed star coral was present between 2014 and 2019 was variable but ranged between about 15% and 30% in Puerto Rico and the Virgin Islands. Between 2014 and 2019, lobed star coral was present at about 10% to 30% of sites in the Florida Keys, at <5% of sites in southeast Florida, and at <10% of sites in the Dry Tortugas (NMFS 2022c).

Density information is available from monitoring programs using permanent and random sites. In permanent sites, the density of lobed star coral in Florida decreased from approximately 0.04 colonies m⁻² in 2014 to about 0.02 colonies m⁻² in 2019. This trend was primarily influenced by lobed star coral density in the Florida Keys that decreased from about 0.07 colonies m⁻² to 0.03 colonies m⁻² over this period. Density of lobed star coral at monotypic/special habitat sites in Florida also decreased between 2014 and 2019, and the trend was primarily driven by sites in the Dry Tortugas. Unpublished monitoring data from random sites stratified by habitat type (different sites visited each year) show that density of lobed star coral was variable between 2014 and 2019 but ranged between 0.05 and 0.15 colonies m⁻² in Puerto Rico and the United States Virgin Islands (NMFS 2022c).

Additional unpublished data from randomly surveyed sites include colony size and partial mortality. Mean colony size was relatively stable between 2014 and 2019 for the United States Virgin Islands, Puerto Rico, and the Florida Keys and ranged between 25 and 50 cm. Average colony size in the Dry Tortugas was highly variable but was approximately 125 cm in 2018. Mean colony partial mortality was between 25% and 50% in Puerto Rico and the United States Virgin Islands and highest in the Florida Keys, ranging from 50% to 75% (NMFS 2022c).

The demographics of lobed star coral were studied on Tektite Reef in St. John, United States Virgin Islands over a 25-year period (1988-2013) divided into 5 year intervals (Edmunds 2015). Bleaching and hurricanes affected the reef during three five-year intervals from 1988 to 2002 though lobed star coral cover over this period increased from 33% to 49%. It subsequently decreased between 2002 to 2007 to 27% and stabilized at about 28% between 2010 to 2013. Over the 25-year period, colonies greater than 50 cm² became rare, and the abundance of colonies ≤ 50 cm² increased from 58% at the beginning of the study to 92% at the end. Density during this period doubled due to the partitioning of larger colonies into more, smaller colonies. Models suggest that maintenance of conditions present at the end of the study could allow lobed star coral to maintain about 9% cover over 100 years, but with the return to conditions present from 1993-1998, lobed star coral could return to coverage similar to that of 1988 (33% cover) in about 15 years (Edmunds 2015).

A demographics study centered around the effects of two major hurricanes that affected the United States Virgin Islands in 2017 found that the storms decreased lobed star coral cover by 1-4% at the two study sites and resulted in the transition of colonies to smaller size classes (Edmunds 2019). In addition, the storms killed 27% of colonies in the smallest size class at one site and 5% at the other. The study concluded that with the low cover of lobed star coral

distributed among many small colonies, future disturbances may play a more important role in loss of the few remaining genotypes rather than further depressing coral cover (Edmunds 2019).

A demographic study of lobed star coral was undertaken at two sites in Puerto Rico. From 2012 to 2014, 100 colonies were followed for growth, survival, and recruitment and used to estimate population growth rates (Soto-Santiago et al. 2017). Survival overall was 70%, and no recruits were found during the study period. Population growth rates were below equilibrium in both years (range 0.67 to 0.82) and declined between the first and second years of the study. The most frequent condition was to remain in the smallest size class ($\leq 50 \text{ cm}^2$), and growth was mainly from small to medium (51-150 cm^2) colonies. More colonies shrank than grew to larger size classes. The study suggests that even in the absence of major disturbance, the vital rates (growth survival, and recruitment rates) of lobed star coral can be susceptible to local variations in environmental parameters (Soto-Santiago et al. 2017).

As discussed above, stony coral tissue loss disease (SCTLD) has greatly impacted coral populations in Florida and the U.S. Caribbean, including the lobed star coral. In surveys of 14 sites off southeast Florida between 2013 and 2015, the prevalence of SCTLD was 77% of lobed star coral colonies surveyed (Precht et al. 2016). Lobed star coral was one of the species in surveys that showed the highest prevalence of disease, and populations were reduced to $< 25\%$ of the initial population size (Precht et al. 2016). In surveys in southeast Florida after Hurricane Irma in 2017, disease affected 67% of lobed star coral colonies and impacted 11% of sites surveyed (243 out of 2,130) (Walker 2018). In the United States Virgin Islands long-term monitoring transects, overall initial prevalence of SCTLD in lobed star coral was about 8% when disease was first reported at a site (Brandt et al. 2021). However, over time, prevalence increased to 100%, reducing the number of colonies in the transects from 81 colonies present between 2005 and 2018 before SCTLD arrived to only 3 by the end of the study (Brandt et al. 2021).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the United States Virgin Islands in 2017. Hurricane impacts included large, overturned and dislodged coral heads and extensive burial and breakage. At 153 survey locations in Puerto Rico, approximately 43-44% of lobed star corals were impacted (NOAA 2018b). In Florida, approximately 80% of lobed star corals surveyed at 57 sites were impacted (Florida Fish and Wildlife Conservation Commission, unpublished data). Survey data are not available for the United States Virgin Islands, though qualitative observations indicate that damage was also widespread but variable by site.

Lobed star coral was historically considered to be one of the most abundant species in the Caribbean (Weil and Knowton 1994). However, lobed star coral populations have continued to decline in abundance, dominance, and cover in some locations, such as Cuba (González-Díaz et al. 2018) (Caballero Aragón et al. 2019), the Florida Keys (NMFS 2022c), and the United States Virgin Islands (Edmunds 2015; Edmunds 2019). Partial mortality of larger colonies has continued to result in a shift to smaller size classes. Periods of growth may occur between disturbance events, but the frequency of events prevents recovery to larger size classes. Although

considered common at the time of listing, the presence of lobed star coral colonies is becoming less common in some locations. The percentage of sites where lobed star coral is present ranges from about 5% to 30% in locations for which data are available with no overall obvious decreasing trends. The buffering capacity of lobed star coral's life history strategy that allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. Low recruitment and slow growth rates impede recovery from disturbance events. Population abundance is likely to decrease in the future with increasing threats.

Mountainous Star Coral

Mountainous star coral occurs in the western Atlantic and throughout the Caribbean, including Bahamas, FGBNMS, and the entire Caribbean coastline. There is conflicting information on whether or not it occurs in Bermuda. Mountainous star coral has been reported in most reef habitats and is often the most abundant coral at 33-66 ft (10-20 m) in fore-reef environments. The depth range of mountainous star coral has been reported as approximately 1.5-132 ft (0.5-40 m), though the species complex has been reported to depths of 295 ft (90 m), indicating mountainous star coral's depth distribution is likely deeper than 132 ft (40 m). Star coral species are a common, often dominant component of Caribbean mesophotic reefs (e.g., > 100 ft; 30 m) suggesting the potential for deep refugia for mountainous star coral.

Unpublished monitoring data indicate that between 2014 and 2019, the percentage of randomly surveyed sites where mountainous star coral was present was approximately 30-45% in the United States Virgin Islands and Puerto Rico. The percentage of sites with mountainous star coral was stable for Puerto Rico and St. Croix during this period but decreased slightly in St. Thomas/St. John. In the Florida Keys and Dry Tortugas, the percentage of sites with mountainous star coral present was highly variable between 2014 and 2020, ranging from 25% to 60% in the Dry Tortugas and from 35% to 80% in the Florida Keys with no obvious indication of declining trends overall for either location. In southeast Florida, the percentage of sites with mountainous star coral was highest in 2014 at about 20%, decreased to a low of <5% in 2016, then increased and stabilized to about 10% from 2017 to 2020 (NMFS 2022).

Unpublished monitoring data from long-term benthic monitoring programs show that in permanent monitoring sites in Florida, the amount of mountainous star coral live tissue decreased between 2014 and 2019. Regional trends show more stable live tissue area in the Dry Tortugas and declines in the Florida Keys and southeast Florida. Overall density of mountainous star coral in Florida decreased slightly between 2014 and 2019 from about 0.1 colonies m⁻² to about 0.08 colonies m⁻². Density was highest in the Dry Tortugas but decreased from about 0.3 colonies m⁻² in 2014 to about 0.2 colonies m⁻² in 2019. In the Florida Keys, density was lower at about 0.1 colonies m⁻² but was relatively stable between 2014 and 2019. Density was lowest in southeast Florida and was typically <0.05 colonies m⁻². In monotypic and special habitat sites in Florida, density increased between 2014 and 2019 (NMFS 2022).

In stratified random surveys (different sites visited each year), average density of mountainous star coral was relatively stable at around 0.25 colonies m⁻² in St. Croix, United States Virgin Islands between 2014 and 2019, but decreased in St. Thomas/St. John from about 0.2 colonies m⁻² in 2015 to about 0.1 colonies m⁻² in 2019. In Puerto Rico, average density was more variable and fluctuated between 0.15 and 0.2 colonies m⁻² between 2015 and 2019 (NMFS 2022).

Other data from random surveys include colony size and partial mortality. Average colony size in the United States Virgin Islands and Puerto Rico was stable at approximately 30 cm between 2014 and 2019. In southeast Florida, average colony size decreased from about 50 to 40 cm between 2014 and 2019. The Florida Keys experienced a larger decline from about 70 cm to about 50 cm average colony size between 2014 and 2018, while the Dry Tortugas was more stable over this same time period with an average colony size of about 55 to 60 cm. Partial colony mortality was generally between 25% and 50% for Florida with increases in southeast Florida and the Dry Tortugas and decreases in the Florida Keys during the 2014 to 2019 time period. Partial colony mortality in Puerto Rico and the United States Virgin Islands was fairly stable at $\leq 25\%$ between 2014 and 2019 (NMFS 2022).

In permanent monitoring stations in the United States Virgin Islands, percent cover of mountainous star coral was relatively stable at about 0.5% between 2015 and 2020. Sites deeper than 21 m showed slight declines followed by increases in cover while the shallower sites showed more variable patterns (NMFS 2022).

The reproductive performance of mountainous star coral was investigated in the United States Virgin Islands over a depth distribution of 5-40 m to assess the contribution of deeper mesophotic populations to regional larval pools (Holstein et al. 2015). Mesophotic populations produced over an order of magnitude more eggs than nearby shallow populations due to population abundance and polyp fecundity. This finding suggests that mesophotic populations are important as reproductive refugia (Holstein et al. 2015).

As discussed above, the effects of SCTLD have been severe, causing mortality of millions of coral colonies across multiple species, including mountainous star coral. Because almost all colonies succumb completely to SCTLD, prevalence is a good indicator of mortality rate (Precht et al. 2016). At study sites in southeast Florida, prevalence of disease was recorded at 67% of all coral colonies and 81% of colonies of those species susceptible to the disease (Precht et al. 2016). In the United States Virgin Islands long-term monitoring transects, overall initial prevalence of SCTLD in mountainous star coral was about 12% when disease was first reported at a site (Brandt et al. 2021). However, over subsequent surveys, prevalence rose as high as about 45%, reducing the abundance of mountainous star coral colonies from 684 colonies present in the transects between 2005 and 2018 before SCTLD arrived, to just 12 colonies by the end of the study (Brandt et al. 2021).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the United States Virgin Islands in 2017. Hurricane impacts included large, overturned and dislodged coral

heads and extensive burial and breakage. At 153 survey locations in Puerto Rico, approximately 12-14% of mountainous star corals were impacted (NOAA 2018). In Florida, approximately 24% of mountainous star corals surveyed at 57 sites were impacted (Florida Fish and Wildlife Conservation Commission, unpublished data). Survey data are not available for the United States Virgin Islands, though qualitative observations indicate that damage was also widespread but variable by site.

Mountainous star coral is still present at a relatively large percentage of sites in Florida, Puerto Rico, and the United States Virgin Islands. Mountainous star coral has had mixed population trends with some decline and some stability. Live cover and average colony size of mountainous star coral have decreased in some areas such as the Florida Keys and southeast Florida but have remained more stable in others such as the United States Virgin Islands, Puerto Rico, and the Dry Tortugas. Partial colony mortality has increased in Florida while remaining lower and more stable in the United States Virgin Islands and Puerto Rico. Density has remained relatively stable in most locations surveyed. We conclude that the buffering capacity of mountainous star coral's life history strategy, which allowed it to remain abundant, has been reduced by the recent population declines and amounts of partial mortality. We also conclude that the population abundance is likely to decrease in the future with increasing threats.

Critical Habitat

Critical habitat was designated in August 2023 for Caribbean coral species (88 FR 54026, 08/09/2023). See Section 4.1.3 Atlantic/Caribbean Corals - Designated Critical Habitat for details.

Recovery Goals

- No final recovery plan currently exists for boulder star, lobed star, or mountainous star coral; however, a recovery outline was developed in 2014 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the five coral species listed in 79 FR 53852; September 10, 2014. The recovery goals are the same for all five species with short and long-term goals. The following contains the recovery goals listed in the document:
- Short Term Goals:
 - Increase understanding of population dynamics, population distribution, abundance, trends, and structure through research, monitoring, and modeling;
 - Increase understanding of genetic and environmental factors that lead to variability of bleaching and disease susceptibility through research;
 - Decrease locally-manageable stress and mortality sources (e. g. , acute sedimentation, nutrients, contaminants, over-fishing); and

- Prioritize implementation of actions in the recovery plan for elkhorn and staghorn corals that will benefit pillar coral, rough cactus coral, boulder star coral, lobed star coral, and mountainous star coral.
- Long Term Goals:
 - Cultivate and implement U. S. And international measures to reduce atmospheric carbon dioxide concentrations to curb warming and acidification impacts and possibly disease threats; and
 - Implement ecosystem-level actions to improve habitat quality and restore keystone species and functional processes to maintain adult colonies and promote successful natural recruitment.

4.2.25 Queen Conch

NMFS listed the queen conch as threatened under the ESA on February 14, 2024 (89 FR 11208). The queen conch is distributed throughout the Caribbean Sea, the Gulf of America, and around Bermuda (Figure 49). Its range includes the following countries, territories, and areas: Anguilla, Antigua and Barbuda, Aruba, Barbados, The Bahamas, Belize, Bermuda, Bonaire, British Virgin Islands, Brazil, Cayman Islands, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Grenada, Guadeloupe and Martinique, Guatemala, Haiti, Honduras, Jamaica, Mexico, Montserrat, Nicaragua, Panama, Puerto Rico, Saba, St. Barthelemy, St. Martin, St. Eustatius, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos, U.S. Virgin Islands, the United States (Florida), and Venezuela (Horn et al. 2022).



Figure 49. Map of the Geographic Distribution of Queen Conch

Life History

After the eggs hatch, queen conch larvae (veligers) drift in the water column up to 30 days depending on phytoplankton concentration, temperature, and the proximity of settlement habitat. These veligers are found primarily in the upper few meters of the water column where they feed on phytoplankton (Stoner and Appeldoorn 2021). When the veligers are morphologically and physiologically ready, they metamorphose into benthic animals in response to trophic cues from their seagrass habitat (Stoner and Appeldoorn 2021). The key trophic cues shown to induce metamorphosis are epiphytes associated with macroalgae and sediment (Stoner and Appeldoorn 2021). Settlement locations are usually areas that have sufficient tidal circulation and high macroalgae production.

Juvenile queen conch are primarily associated with native seagrass, such as *Thalassia testudinum*, in large parts of their range in the Caribbean and the southern Gulf of America (Boman et al. 2019). However, juvenile queen conch can occur in a variety of habitat types. Randall (1964) reported that juvenile conch in the U.S. Virgin Islands were most abundant in shallow coral-rubble environments, with lower densities on bare sand and in seagrass beds. A similar association was reported from Puerto Rico, with high numbers in coral rubble compared with sand, seagrass, and hard bottom (NMFS 2014b). In Florida, juveniles are found in a variety of habitats, including reef rubble, algae-covered hard bottom, and secondarily in mixed beds of algae and seagrass, depending upon general location (Glazer and Berg Jr. 1994). In Cuba, the Turks and Caicos Islands, Venezuela, and The Bahamas, juvenile conch are associated primarily with native seagrass (NMFS 2014b). In St. Croix, U.S. Virgin Islands, densities of juvenile and adult queen conch were the highest in habitats characterized as 50-90% and 10-50% patchy seagrass, respectively (NMFS 2014b).

After the veligers settle on the bottom, they bury into the sediment. This submerged life phase makes it difficult to survey and therefore they are often under-sampled. They emerge about a year later as juveniles at around 60 mm (2.4 inch) shell length (NMFS 2014b).

Most conch nursery areas occur primarily in back reef areas (i.e., shallow sheltered areas, lagoons, behind emergent reefs or cays) of medium seagrass density, depths between 2 to 4 m (3.3 to 13.1 ft), with strong tidal currents, and frequent tidal water exchanges (Horn et al. 2022). Seagrass is thought to provide both nutrition and protection from predators (Horn et al. 2022). The structure of the seagrass beds decreases the risk of predation, which is very high for juveniles (Horn et al. 2022). Posada et al. (1997) observed that the most productive nurseries for queen conch tended to occur in shallow seagrass meadows (less than 5 to 6 m [16.4 to 19.7 ft] deep).

Adult conch can be found in a wide range of environmental conditions (Stoner et al. 1994) such as in sand and algal or coral rubble (Acosta 2001; Stoner and Davis 2010). Adult queen conch are rarely, if ever, found on soft bottoms composed of silt and/or mud, or in areas with high coral cover (Horn et al. 2022). Adult conch are found in shallow, clear water of oceanic or near-oceanic salinities at depths generally less than 75 m (246 ft), and are most often found in waters

less than 30 m (98.4 feet; McCarthy 2007). It is believed that depth limitation is based mostly on light attenuation limiting their photosynthetic food source (Randall 1964; McCarthy 2007).

Population Dynamics

Queen conch inhabit a range of habitat types during their life cycle. As conch develop they use different habitat types including seagrass beds, sand flats, algal beds, and rubble areas from a few centimeters deep to approximately 30 m (98.4 feet; NMFS 2014b).

Early genetic studies of queen conch using electrophoretic methods found a high degree of gene flow among populations dispersed over the species' geographic distribution, with definitive separation observed only between populations in Bermuda and those in the Caribbean basin (Mitton et al. 1989). Although Mitton et al. (1989) found limited evidence of population structure in the Caribbean, the authors hypothesized that the complex ocean currents of the Caribbean may restrict gene flow among Caribbean populations, even though larvae may disperse long distances throughout the Caribbean during their 16-28 day pelagic larval duration. Truelove et al. (2017) used microsatellite markers and a comprehensive sampling strategy to perform a detailed study of queen conch spatial genetic structure across the greater Caribbean seascape. Microsatellite genetics identified significant levels of genetic differentiation among Caribbean sub regions (e.g., Florida Keys, Mesoamerican Barrier Reef, Lesser Antilles, Honduran/Jamaican Banks, Greater Antilles, and Bahamas) and between the eastern and western Caribbean regions (Truelove et al. 2017). The connectivity model from Vaz et al. (2022) indicates there are several important jurisdictions that act as steppingstones in facilitating population connectivity in the Caribbean region. For example, loss of Puerto Rico mesophotic populations would likely result in the loss of the genetic connectivity between the southeastern and western Caribbean. Furthermore, the connectivity model and literature suggest that the Nicaraguan rise, which includes the territorial seas of Honduras, Nicaragua, Colombia, and Jamaica, is likely to be an important region for maintaining population connectivity over larger spatial scales. These findings are similar to those observed in Truelove et al. (2017). Many of these jurisdictions are currently overexploiting their conch populations. If this trend continues, those populations will likely continue to decrease to the point of impaired reproduction in the foreseeable future, further disrupting the flow of larvae throughout the region and decreasing genetic diversity.

Total population abundance estimate for queen conch ranges from 451 million to 1.49 billion individuals, based on the 10th and 90th percentile abundance estimates across jurisdictions (Horn et al. 2022). Those estimates, however, required numerous assumptions, in particular the assumed extent of conch habitat. In addition, for many areas, available survey data were limited, were outdated (may have been collected decades ago), or were unavailable. In many cases, survey methods and data collected (e.g., was abundance of adults or of all conch reported) were poorly described (Horn et al. 2022).

Many queen conch populations are presently below the densities required to support reproductive activity due to low encounter rates or mate finding. Based on the available data, it is likely that recruitment failure is occurring throughout a large portion of the species' range. Continued

declines in abundance and evidence of overfishing suggest that population growth rates are below replacement. There are only a handful of jurisdictions [i.e., St. Lucia, Saba, Jamaica (Pedro Bank), Nicaragua, Turks and Caicos, Costa Rica, Cuba, Colombia (Serrana Bank), and The Bahamas (Cay Sal Bank and Jumentos and Ragged Cays)] that have adult conch densities (>100 adult conch per hectare) sufficient to sustain successful reproductive activity. The majority of jurisdictions have adult densities below the critical threshold of 50 adult conch per hectare required for any reproductive activity (i.e., Anguilla, Antigua and Barbuda, Aruba, The Bahamas' Western/Central Great Bahama's Bank, Little Bahama's Bank, Barbados, Belize, Bermuda, Bonaire, British Virgin Islands, Colombia's mainland, Quitasueño and Serranilla Bank, Curaçao, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Martinique, Mexico, Montserrat, Panama, St. Maarten, St. Vincent and the Grenadines, St. Barthelemy, Trinidad and Tobago, Florida, Puerto Rico, U.S. Virgin Islands, and Venezuela). Several additional jurisdictions have densities that are below the 100 adult conch per hectare minimum threshold for successful reproductive activity (i.e., Cayman Islands, Honduras, St. Eustatius, Saint Kitts and Nevis, and Puerto Rico's mesophotic reef). In other words, the population growth rates in the majority of jurisdictions are likely below replacement levels given their lower densities and thus are at increased risk for negative impacts due to compensatory processes. There is also evidence of growth overfishing of queen conch, such as in Belize, which has led to the development of smaller adult conch. Since smaller conch are thought to be less productive (i.e., lower mating frequencies, smaller gonads, fewer eggs), the decrease in the sizes of adult queen conch will likely lead to decreases in abundance and lower densities, further contributing to declines in populations in the foreseeable future (Horn et al. 2022).

Status

Queen conch has been fished in the western tropical Atlantic since prehistoric times, but in the last four decades, fishing has increased and industrial scale fishing has developed (NMFS 2014b). In most range states, conch fishing continues although population densities are quite low; with conch populations, either experiencing reduced reproductive activity or densities are insufficient to support consistent reproductive activity. NMFS identified the following as threats that are significantly contributing to the queen conch extinction risk: commercial and artisanal fishing, illegal and/or unreported fishing, existing regulations, enforcement, and changing environmental conditions. The combination of continued exploitation, depleted reproductive potentials, and unquantified fishing pressures is cause for concern for the status of queen conch.

Critical Habitat

No critical habitat has been designated for queen conch.

Recovery Goals

NMFS has not prepared a recovery plan for queen conch.

5 ENVIRONMENTAL BASELINE

The *environmental baseline* refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from Federal agency activities or existing Federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR §402.02).

5.1 Large-Scale Changes in Environmental Conditions

There is a large and growing body of literature on past, present, and future impacts of global environmental changes driven by elevated greenhouse gas emissions. The average temperature on land and in the ocean has continued to rise over the last 150 years (Figure 50; IPCC (2023)). The average global surface temperature was 1.09°C higher from 2011 to 2020 than from 1850 to 1906, with larger increases over land (1.59°C) than over the ocean (0.88°C) (IPCC 2023). Global surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2000 years, and 2024 was the hottest year on record. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018). In the continental U.S., annual average temperatures have increased by 1.8°C since the beginning of the 20th century, and warming is increasing around 60% faster than the global average since 1970 (Jay et al. 2018; Marvel et al. 2023; USGCRP 2023). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves. Average global warming up to 1.5°C as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (USGCRP 2023).

This warming has triggered many changes in the earth's climate, with numerous independent lines of evidence documenting these changes occurring from the atmosphere to the ocean to the poles. This warming, primarily in response to human activities, is causing widespread effects in the physical environment (Wuebbles et al. 2017). Changing environmental conditions have led to increased frequency, severity, and magnitude of severe weather events like storms and hurricanes, which have resulted in greater storm damage and erosion in coastal areas. Additionally, environmental changes are also causing sea level rise, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact marine ecosystems and ESA-listed species and their habitats. NOAA's climate information portal provides basic and updated background information on these and other measured or anticipated effects of changing environmental conditions (see <https://www.climate.gov>).

Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred and changing environmental conditions are already affecting many weather and climate extremes in every region across the globe (IPCC 2023). These effects are especially well-documented in the ocean and coastal regions. Between 1993 and 2019, consistent and pronounced warming has been observed across the global oceans, especially associated with key boundary currents (Johnson et al. 2020). Global mean sea level increased by 0.20 m between 1901 and 2018, and the average rate of sea level rise has increased from 1.3 mm per year between 1901 and 1971 to 3.7 mm per year between 2006 and 2018. In the U.S., coastal sea levels are predicted to rise 28 cm between 2020 and 2050, leading to greater probability of flooding (USGCRP 2023).

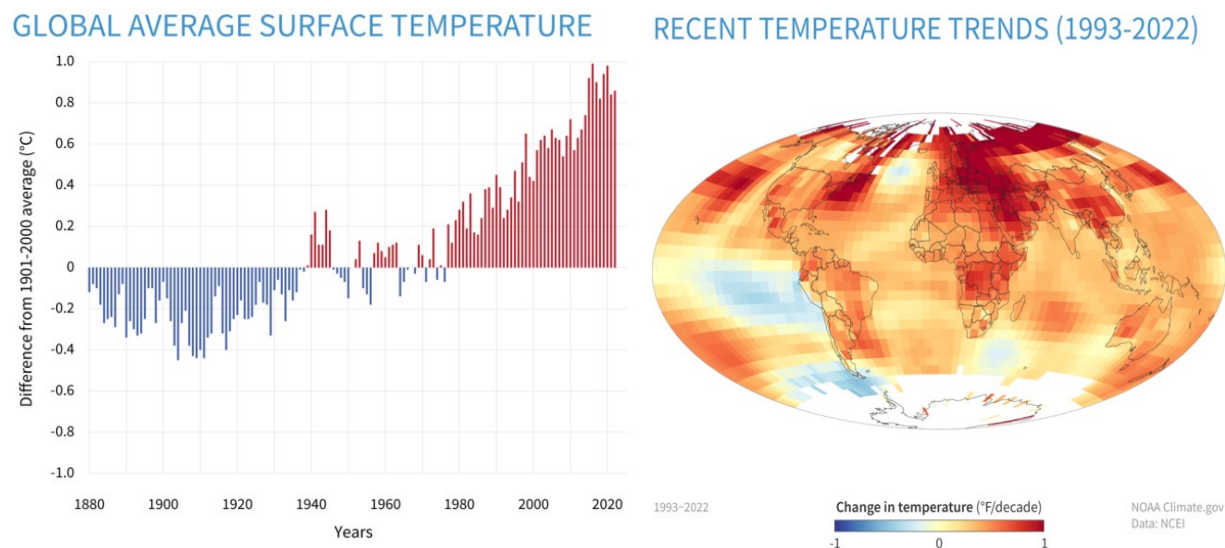


Figure 50. Global Annual Average Temperature (a) Yearly Surface Temperature Compared to the 20th Century Average from 1880-2022 (NOAA climate.gov)

The Atlantic Ocean, particularly the North Atlantic, is warming significantly faster than most other ocean basins, second only to the Southern Ocean, and is projected to continue to experience substantial warming in the upper 2,000 m even under conservative emissions scenarios (Cheng et al. 2022). On average, the general warming trend in the North Atlantic Ocean over the last 80 years is 0.031 ± 0.0006 °C per decade in the upper 2,000 m (6,561.7 ft) of the ocean (Polyakov et al. 2009). Changing environmental conditions are expected to have a number of impacts to the marine ecosystem in the Gulf of America. Temperature profiles have been collected in the Gulf of America since the 1920s. The Gulf of America region has experienced a warming rate of approximately 0.193 °C decade⁻¹ since 1970, and has warmed at least 1.0 °C in the past 50 years (Wang et al. 2023). The rate at which the Gulf of America is warming is twice that off the global ocean (0.086 °C per decade), but only slight higher than the warming trend in the subtropical northern Atlantic Ocean (0.183 °C per decade) (Wang et al. 2023).

One consequence of warming waters in the Gulf of America is exacerbation of hypoxic conditions into what is referred to as the “dead zone.” The “dead zone” refers to a large area of low oxygen water that develops every summer near the Mississippi River Delta caused by excessive nutrient pollution into and freshwater discharge from the Mississippi River basin, due to changes in oxygen solubility, water stratification, and primary productivity (Bianchi et al. 2010; Altieri and Gedan 2015; Laurent et al. 2018). Changes to the marine biophysical environment are also affecting the growth and movement dynamics of pelagic *Sargassum* in the Gulf of America; *Sargassum* is designated as critical habitat for juvenile green sea turtles (Sanchez-Rubio et al. 2018; Marsh et al. 2023).

Through physical and biological interactions between the atmosphere and ocean, changing environmental conditions are significantly altering marine life and ecosystems in the U.S. Changing environmental conditions have the potential to impact species abundance, geographic distribution, migration patterns, susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (MacLeod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006; McMahon and Hays 2006; Evans and Bjørge 2013; IPCC 2014; USGCRP 2023). Recent peer-reviewed research has provided additional evidence that long-term warming and changes in ocean circulation have altered the migration timing of marine species (Langan et al. 2021). In the Gulf of America, fish and invertebrate species shifted to deeper regions, rather than exhibiting a pole-ward shift like other continental shelf species assemblages in North America (Pinsky et al. 2013). Along the Texas coast, over a 35-year timeframe researchers observed 32 species exhibiting range shifts, either expanding or contracting their expected distribution due to changing environmental factors (Fujiwara et al. 2019).

These changes in species distributions and community structure could potentially affect ESA-listed species. Though predicting the precise consequences of changing environmental conditions on highly mobile marine species is difficult (Simmonds and Isaac 2007), recent research has indicated a range of consequences already occurring. Marine mammal species with restricted geographical distributions and habitat tolerances will have limited opportunities to adapt to the changing conditions of their environment. Macleod (2009) estimated, based upon expected shifts in water temperature, 88% of marine mammals will be affected by changing environmental conditions, with 47% predicted to experience unfavorable conditions (e.g., range contraction). Marine mammals rely on stable environments where prey availability is relatively predictable (Lettrich et al. 2023). Changes in the marine ecosystems caused by large-scale environmental changes could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, and forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. For example, as feeding specialists, blue whales are likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1986; Payne et al. 1990; Clapham et al. 1999). Pecl and Jackson (2008) predicted changing environmental conditions will likely result in squid that hatch out smaller and earlier, undergo

faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Elliott 2009).

Vulnerability assessments can provide a framework for evaluating the impacts of changing environmental conditions over a broad range of species using currently available information. Vulnerability to changing environmental conditions was determined to be very high for 47 U.S. marine mammal stocks in the North Atlantic, Gulf of America, and Caribbean when exposure (projected change in environmental conditions) and sensitivity (ability to tolerate and adapt to changing conditions) were assessed to categorize stocks with a vulnerability index (Lettrich et al. 2023). Based on this assessment, the overall vulnerability rank was either “High” (fin, sei, blue, and sperm whales) or “Very High” (Rice’s and North Atlantic right whales) for all ESA-listed marine mammal species considered in this opinion (Lettrich et al. 2023). Temperature, ocean pH, and DO were the primary drivers, which, in turn, impacted prey and habitat parameters. The Gulf of America was also considered to be “highly” or “very highly” vulnerable to changing environmental conditions in this study.

Environmental conditions can influence marine mammal female body condition and impact reproductive success via changes in prey, from distribution and abundance to composition and caloric value (Keen et al. 2021). Changes in prey availability can occur across a range of spatial and temporal scales, from hour-long tidally driven hotspots and mesoscale features that can persist for months (e.g. eddies and fronts) to ocean basin-wide shifts resulting from within- (e.g. seasonal variability) and between-year (e.g. climatic oscillations) variability (Keen et al. 2021). Changing environmental conditions affect these natural oceanographic and atmospheric processes and, subsequently, the distribution and viability of marine mammal populations.

Evans et al. (2025) used data from NOAA’s Ecosystem Monitoring Program (1980-2019) to assess spatiotemporal changes in the abundance of copepod prey and implications for right whale foraging energetics. They found that increases in the abundance of smaller copepods in the Gulf of Maine since 2010 have been insufficient to compensate energetically for the decline in *Calanus finmarchicus*, which has a much higher energy content compared to the smaller copepods (Evans et al. 2025). Further ocean warming, predicted to negatively impact *C. finmarchicus* and positively impact smaller copepods, may influence whether traditional foraging grounds can support large numbers of foraging North Atlantic right whales (Evans et al. 2025; Johnson et al. 2025).

Sea turtles are affected by multiple threats associated with changing environmental conditions across their different life stages (Patrício et al. 2021). Changing environmental conditions have, therefore, been described as a threat multiplier that interacts in additive and synergistic ways with almost all other stressors that sea turtles face (Staudt et al. 2013; Fuentes et al. 2023). Notably, sex is determined by the ambient sand temperature (during the middle third of

incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35°C (Ackerman 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (Fuentes et al. 2024). Over time, this can reduce genetic diversity, or even population viability, if males become a small proportion of populations (Hulin et al. 2009). Rising incubation temperatures can also decrease hatching success and hatchling fitness (Santidrián Tomillo et al. 2012; Montero et al. 2018). Sea surface temperatures on loggerhead foraging grounds has also been linked to the timing of nesting, with higher temperatures leading to earlier nesting (Mazaris et al. 2009; Schofield et al. 2009). Green sea turtles emerging from nests at cooler temperatures likely absorb more yolk that is converted to body tissue than do hatchlings from warmer nests (Ischer et al. 2009). However, warmer temperatures may also decrease the energy needs of a developing embryo (Reid et al. 2009).

Additionally, sea level rise may cause the loss of nesting areas and higher clutch mortality due to seawater inundation (Lyons et al. 2020). Extreme weather events, which are predicted to occur more frequently with changing environmental conditions, can destroy nests and alter hatchling dispersal patterns (DuBois et al. 2020). For in-water life stages, future changes in environmental conditions may push sea turtles into novel regions and habitats where they experience new anthropogenic, trophic, and ecological interactions (Fuentes et al. 2020).

Information on current effects of changing environmental conditions on ESA-listed anadromous fish species is not available. While it is speculated that future environmental changes may affect salmon and sturgeon, it is difficult to predict the magnitude and scope of those potential impacts. Atlantic sturgeon and Atlantic salmon could be affected by changes in river ecology resulting from increases in precipitation and changes in water temperature which may affect recruitment and distribution in these rivers. The effects of increased water temperature and decreased water availability are likely to have a more immediate effect on fish populations that migrate and spawn in river systems with existing water temperatures that are at or near the maximum for the species, including the South Atlantic and Carolina DPSs of Atlantic sturgeon. Atlantic sturgeon prefer water temperatures up to approximately 28°C (82.4°F); these temperatures occur naturally in some areas of rivers during the summer months. If river temperatures rise above 28°C in larger areas, sturgeon may be excluded from certain habitats. The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas, while flooding events could cause temporary decreases in water quality. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with changes in DO and temperature.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to anadromous fish spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with changing

environmental conditions are likely to disrupt river ecology, leading to shifts in community structure and changes in the type and abundance of prey species. Additionally, environmental cues for spawning migration and spawning could occur earlier in the season causing a mismatch between the timing of prey availability and the needs of developing sturgeon and salmon in their rearing habitat.

Changes in oceanic conditions could also affect the marine distribution of sturgeon and salmon or their marine and estuarine prey resources. Rising sea level may result in the salt wedge moving upstream in affected rivers. Anadromous fish spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. In river systems with dams or natural falls that are impassable by sturgeon, movement of the salt wedge further upstream would further restrict spawning and rearing habitat. The effects of changing environmental conditions on ESA-listed sturgeon and salmon will not occur independently from other stressors. Rather, the anthropogenic stressors already affecting the fitness and survival of these species – including bycatch, loss of migratory habitat from dams, contamination of riverine habitat and overall decreased water quality – will be compounded by the anticipated effects of changing environmental conditions.

Habitat loss due to changing environmental conditions represents a primary threat to smalltooth sawfish (Brame et al. 2019). Red mangroves and shallow (<1 m), euryhaline waters identified as habitat features essential for the conservation of smalltooth sawfish are likely to be affected by changing environmental conditions, most notably through sea level rise (Brame et al. 2019). Sea level increases would reduce the amount of shallow water available for juvenile smalltooth sawfish in areas where shorelines are armored (e.g. seawalls). Reductions in the availability of shallow water or mangroves could have numerous ecological effects on sawfish, including increased sawfish predation, higher metabolic stress, and decreased body condition (Brame et al. 2019). In addition, smalltooth sawfish require specific salinities to maintain proper fluid levels in their bodies. Weather shifts due to changing environmental conditions can lead to variable inputs of freshwater into their coastal habitats. These events can alter saline concentrations, which may result in juvenile sawfish having to travel farther up or down rivers to meet their salinity requirements. Given that sawfish distribution is limited to areas with water temperatures above 8–12°C, warming could result in a northward range expansion for the species. Increased air temperature may also allow northward expansion of red mangroves, thus providing a primary habitat feature for the species outside of the current range (Brame et al. 2019)

ESA-listed corals are susceptible to multiple impacts from changing environmental conditions including bleaching events due to elevated sea surface temperatures, severe hurricanes and swells, ocean acidification and sea level rise. During periods of thermal stress, the corals expel their symbiotic zooxanthellae (known as “coral bleaching”), which removes a primary energy and oxygen source for the coral. Coral bleaching can occur as a stress response to changes in light availability, nutrients, toxicants, or pathogens. On a global scale, bleaching events have increased in frequency and have been on the rise for decades.

Major hurricanes have caused significant losses in coral cover and changes in the physical structure of many reefs in the action area, as well as loss or damage to seagrass beds from blowouts and sediment movement. For example, coral reef surveys after two major hurricanes (Irma and Maria) hit Puerto Rico in 2018 showed that 11% of corals had experienced damage where the colony was broken, overturned, upside down or loose (Viehman et al. 2020). Damaged colonies may be more susceptible to bleaching, disease, boring organisms and algae overgrowth. Tropical storms and hurricanes can also result in severe flooding, leading to significant sediment transport to nearshore waters from terrestrial areas, as well as shifting of marine sediments. In addition to affecting sessile benthic organisms such as ESA-listed corals, changes in the structure of the reef can affect ESA-listed fish species. For example, Nassau grouper as juveniles use shallow nearshore habitats as nursery areas and adults use deeper coral habitats for refuge and foraging, and scalloped hammerhead sharks also use these habitats for foraging and, in some cases, as nursery areas.

For ESA-listed corals and mollusk (e.g., queen conch) species that form calcium carbonate shells, one of the greatest threats contributing to their extinction risk is ocean acidification driven by large-scale changes in environmental conditions (Scherer et al. 2022). The rapid increase in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the mid-19th century are significantly altering the carbonate chemistry of the ocean (IPCC 2023). Ocean acidification occurs as carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean, and is predicted to increase considerably between now and 2100 (IPCC 2023).

Changing environmental conditions affect ecological processes and interactions, including parasitism (see Section 5.13)(Byers 2021). For parasites not killed by rising temperatures, some simple physiological rules, including the tendency of temperature to increase the metabolism of ectotherms and increase oxygen stress on hosts, suggest that parasites' intensity and pathologies might increase (Byers 2021). In addition to temperature, changes in DO, ocean acidity, salinity, and host and parasite distributions also affect parasitism and disease, but these factors are much less studied (Byers 2021).

Our review highlights evidence of major impacts to ESA-listed species and their habitats globally and within the AFTT action area due to large-scale changes in environmental conditions. While it is difficult to accurately predict the consequences of such changes to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats.

5.2 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to multiple sources of anthropogenic sounds. Anthropogenic sound is generated by commercial and recreational vessels, aircraft, sonar, ocean research activities, dredging, construction, offshore mineral exploration, military activities, seismic surveys, and other human activities. These activities occur within the action area to varying degrees throughout the year. ESA-listed species have the potential to be impacted by increased levels of both background sound and high intensity, short-term sounds. Sources of anthropogenic noise are becoming both more pervasive and more powerful, increasing both oceanic background sound levels and peak intensity levels (Hildebrand 2004; Duarte et al. 2021). NMFS has established criteria to predict varying levels of responses of marine species to anthropogenic sound, based upon hearing injury and behavioral responses (<http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm>). Responses to sound exposure may include lethal or nonlethal injury, temporary or permanent hearing impairment, behavioral harassment and stress, or no apparent response.

Sounds are often considered to fall into one of two general types: impulsive and non-impulsive, which differ in the potential to cause physical effects to animals (see Southall et al. 2007 for in-depth discussion). Impulsive sound sources produce brief, broadband signals that are atonal transients and occur as isolated events or repeated in some succession. They are characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury. Non-impulsive sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or non-continuous. Some can be transient signals of short duration but without the essential properties of pulses (e.g., rapid rise time). The duration of non-impulsive sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Anthropogenic sound within the marine environment is recognized as a potential stressor that can harm marine animals and significantly interfere with their normal activities (NRC 2005). The species considered in this opinion may be impacted by anthropogenic sound in various ways. Anthropogenic sounds may produce a behavioral response including, but not limited to, changes in habitat to avoid areas with higher sound levels, changes in diving behavior, or in the case of cetaceans, changes in vocalization (MMC 2007). Many researchers have described behavioral responses of marine mammals to the sounds produced by boats and vessels, as well as other sound sources such as helicopters and fixed-wing aircraft, dredging and construction. Most observations have been limited to short-term behavioral responses, which included temporary cessation of feeding, resting, or social interactions. However, habitat abandonment can lead to more long-term effects, which may have implications at the population level. Interference, or masking, occurs when a sound has a similar frequency and similar to or louder than the sound an animal is trying to hear (Francis 2013). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and

other environmental cues (Richardson 1995). Masking can reduce the range of communication, particularly long-range communication, such as that for blue and fin whales. Recent scientific evidence suggests that marine mammals, including blue and fin whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (Parks 2003; McDonald et al. 2006; Parks 2009).

There are limited data on the hearing abilities of sea turtles, their uses of sounds, and their vulnerability to sound exposure. The functional morphology of the sea turtle ear is poorly understood and debated. Some evidence suggests that sea turtles are able to detect (Bartol and Ketten 2006; Martin et al. 2012) and behaviorally respond to acoustic stimuli (O'Hara and Wilcox 1990; Moein et al. 1995; McCauley et al. 2000a; DeRuiter and Doukara 2012). Sea turtles may use sound for navigation, locating prey, avoiding predators, and general environmental awareness (Dow Piniak et al. 2012).

For fishes, the effects of anthropogenic sound have been well documented. However, due to the sheer diversity and numbers of fish, much remains unknown about fishes' abilities to detect and respond to sound. Sensitivity to sound also varies among fishes, and many fish species have developed sensory mechanisms that enable them to detect, localize, and interpret sounds in their environment. When considering the effects of anthropogenic sound on fishes, it is those sound sources that have the potential to cause physical injury and mortality to the individual or disrupt essential behavioral patterns; and whether or not these effects pose a risk to the population of a particular species that are a great concern. These would be acute or limited in duration sound exposures such as those sounds generated during construction activities, use of explosives, and seismic surveys.

The ESA-listed coral species that occur in the action area are regularly exposed to multiple sources of anthropogenic sounds. There is scientific uncertainty on the extent to which corals have the potential to be impacted by increased levels of both background sound and high intensity, short-term sounds. Low frequency anthropogenic noise, such as boat noise, may disrupt coral larvae's ability to sense, integrate, and respond to settlement cues such as crustose coralline algae odor Ferrier-Pagès (Lecchini et al. 2018; Ferrier-Pagès et al. 2021).

Despite the potential impacts on individual ESA-listed marine mammals, sea turtles, fishes, and invertebrates, information is not currently available to determine the potential population level effects of cumulative anthropogenic sound sources in the marine environment (MMC 2007). For example, we currently lack empirical data on how sound impacts growth, survival, reproduction, and vital rates, nor do we understand the relative influence of such effects on the population being considered. As a result, the consequences of anthropogenic sound on ESA-listed marine mammals, sea turtles, fishes, and invertebrates at the population or species scale remain uncertain.

This section is divided into subsections addressing the impacts of anthropogenic sound from the following major sources: vessels and commercial shipping; seismic surveys; military activities; active sonar; pile driving and construction.

5.2.1 Vessel Sound and Commercial Shipping

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (NRC 2003; Hildebrand 2009b; Mckenna et al. 2012). Shipping constitutes a major source of low-frequency sound in the ocean (Hildebrand 2004), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. Globally, commercial shipping's contribution to ambient noise in the ocean increased by as much as 12 dB between approximately the 1960s and 2005 (Hildebrand 2009a). The relative distribution of commercial vessel traffic (> 65 ft in length) in the AFTT action area (based on data from 2016 to 2023) is shown in Figure 51. Cargo ships account for the greatest proportion (30%) of large vessel traffic within AFTT OPAREAS, followed by tankers (15%), fishing vessels (14%), bulk carriers and service vessels (9% each) (Navy 2025a). While commercial shipping vessels contribute a large portion of oceanic anthropogenic noise, other sources of maritime traffic can be present in large numbers and impact the marine environment particularly in nearshore and inland marine areas. These include smaller recreational boats, whale-watching boats, research vessels, and support vessels associated with oil and gas activities.

Commercial shipping is a significant contributor to ambient noise in the Gulf of America. Haver et al. (2021) recently assessed chronic low-frequency noise from commercial shipping as a global threat to marine animals. Based on monthly vessel activity data, the Gulf of America site had the highest number of overall transits, more than double the number of cargo transits, and five times as many tanker transits compared to other sites, with a monthly average of 91 transits. At the three monitoring sites with high levels of shipping traffic, including the Gulf of America, daily average sound levels were consistently near to or higher than 100 dB re 1 μ Pa in both the 63 and 125 Hz one-third octave. In comparison, sound levels were approximately 20 dB lower year-round in Hawaii and approximately 10 to 20 dB lower in the Alaskan Arctic (depending on season). The highest sound levels measured in the Gulf of America were also the highest sound levels measured across all five sites.

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Propulsion systems are a dominant source of radiated underwater sound emanating from large vessels at frequencies less than 200 Hz (Ross 2013). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Peak spectral levels for individual commercial vessels are in the frequency band of 10 to 50 Hz and range from 195 dB re: μ Pa²-s at 1 m for fast-moving (greater than 20 knots) supertankers to 140 dB re: μ Pa²-s at 1 m for smaller vessels (NRC 2003). Small boats with outboard or inboard engines produce sound that is generally

highest in the mid-frequency (1 to 5 kHz) range and at moderate (150 to 180 dB re: one μPa at 1 m) source levels (Erbe 2002; Gabriele et al. 2003; Kipple and Gabriele 2004). The low frequency sounds from large vessels (e.g., ocean going container ships, tankers, military vessels) overlap with many mysticetes' predicted hearing ranges (7 Hz to 35 kHz) and may mask their vocalizations and cause physiological stress (Rolland et al. 2012; NOAA 2018a). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kHz, which may interfere with important biological functions of odontocetes, including foraging (Holt 2008; Blair et al. 2016).

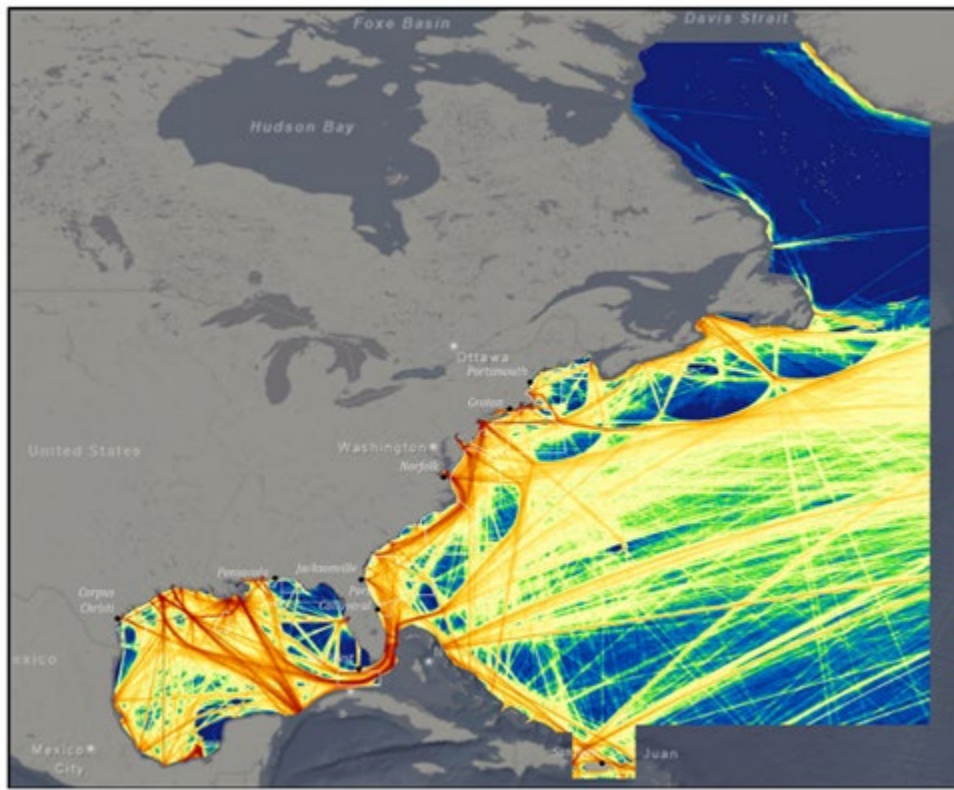


Figure 51. Relative Distribution of Nonmilitary Vessel Traffic (> 65 ft in length) in the AFTT Action Area (Navy 2025a)

5.2.2 Seismic Surveys

Seismic survey activities, including those that involve the use of towed airgun arrays, occur throughout the action area. Offshore seismic surveys involve the use of high energy sound sources operated in the water column to probe below the seafloor for oil and gas exploration. They are the primary exploration technique to locate hydrocarbon deposits, fault structure, and other geological hazards. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} Joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold and Coates 2006). Seismic airgun noise can propagate

substantial distances at low frequencies (e.g., Nieuw Kirk et al. 2004). These activities may produce noise that could impact whales, sea turtles, and fish within the action area.

Airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of 10 to 20 seconds for extended periods (NRC 2003). Most of the energy from airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 dB at dominant frequencies of 5 to 300 Hz (NRC 2003). Most of the sound energy is at frequencies below 500 Hz, which is within the hearing range of baleen whales and sperm whales (Nowacek et al. 2007). In the U.S., seismic surveys involving the use of airguns with the potential to take marine mammals are generally covered by incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. In addition, when the Bureau of Ocean Energy Management (BOEM), the National Science Foundation (NSF), and U.S. Geological Survey (USGS) authorize, fund, and/or conduct these seismic survey activities in domestic, international, and foreign waters, and in doing so, consults with NMFS to ensure their actions do not jeopardize the continued existence of ESA-listed species or adversely modify or destroy designated critical habitat. More information on the effects of these activities on ESA-listed species, including exempted take levels, can be found in recent biological opinions associated with these consultations¹⁹.

BOEM has issued permits for over 12,000 seismic surveys (2D and 3D) in the Gulf of America since the 1953 passage of the Outer Continental Shelf Lands Act and has consulted with NMFS under the ESA on seismic survey permits for oil and gas exploration off the Atlantic coast. Estabrook et al. (2016) found that while abiotic and anthropogenic noise sources significantly contributed to the Gulf of America ambient soundscape, seismic survey noise dominated the noise environment and chronically elevated noise levels across several paramount marine habitats.

Seismic surveys are also used for scientific research, to identify possible seafloor or shallow-depth geologic hazards, and to locate potential archaeological resources and benthic habitats that should be avoided. The NSF funded and the Lamont-Doherty Earth Observatory (L-DEO) conducted seismic surveys in the Northwest Atlantic Ocean on the R/V *Atlantis* in 2018 and R/V *Marcus G. Langseth* in 2014 through 2015 and recently off the coast of North Carolina on the R/V *Marcus G. Langseth* in 2023. The USGS funded and conducted seismic surveys in the Northwest Atlantic Ocean on the R/V *Marcus G. Langseth* in 2014 through 2015 and R/V *Hugh R. Sharp* in 2018. All proposed seismic surveys require a MMPA Incidental Harassment Authorizations (IHA) and are subject to separate ESA section 7 consultations. In 2018, we issued an opinion on the BOEM's issuance of five oil and gas permits for geological and geophysical seismic surveys off the U.S. coast of the Atlantic Ocean and NMFS Permits Division's issuance

¹⁹ Recent biological opinions, sorted by action agency, can be found here: <https://www.fisheries.noaa.gov/national/endangered-species-conservation/biological-opinions-noaa-fisheries-office-protected>

of associated MMPA IHAs. The biological opinions and subsequent monitoring reports for these activities concluded that effects from the airgun array would result in ESA harassment of ESA-listed marine mammals and sea turtles, but would not jeopardize the continued existence of an ESA-listed species. Presently, no oil and gas development is planned for the Mid-Atlantic Ocean and South Atlantic Ocean region, as leasing consideration for waters off North Carolina, South Carolina, Georgia, and Florida were withdrawn.

5.2.3 Active Sonar

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or continuous), rate of repetition, and source level. Sonar systems can be divided into three categories, depending on their primary frequency of operation; low frequency for one kHz and less, mid frequency for one to 20 kHz, and high frequency for 20 kHz and greater²⁰ (Hildebrand 2004). Low frequency systems are designed for long-range detection (Popper et al. 2014). Signal transmissions are emitted in patterned sequences that may last for days or weeks. Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders and communication sonars. High-frequency military sonars includes those incorporated into weapons (torpedoes and mines) or weapon countermeasures (mine countermeasures or anti-torpedo devices), as well as sidescan sonar for seafloor mapping. Commercial sonars are designed for fish finding, depth sounding, and sub-bottom profiling. They typically generate sound at frequencies of 3 to 200 kHz, with source levels ranging from 150 to 235 dB re 1 μ Pa @ 1 m (Hildebrand 2004). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments; however, fish finders are operated in both deep and shallow areas. A more in depth discussion of sonar as an environmental stressor, and the impacts of this stressor on ESA-listed species can be found in Sections 2.4.1.3, 6.1.1, and 6.2.1 of this opinion.

5.2.4 Pile Driving and Construction Sound

Industrial activities and construction both in the ocean and along the shoreline can contribute to underwater noise. Pile driving is commonly used for the construction of foundations for a large number of structures including bridges, buildings, retaining walls, harbor facilities, offshore wind turbines, and offshore structures for the oil and gas industry. Pile driving during construction activities is of special concern because it generates noise with a very high source level. During pile installation, noise is produced when the energy from construction equipment is transferred to the pile and released as pressure waves into the surrounding water and sediments. The impulsive sounds generated by impact pile driving are characterized by a relatively rapid rise time to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures (Illingworth and Rodkin 2007; Reyff

²⁰ Note that the classification of active sonar sources by frequency (i.e., low, mid, high) can vary.

2012). The amount of noise produced by pile driving depends on a variety of factors, including the type and size of the impact hammer, size of the pile, the properties of the sea floor, and the depth of the water. The predominant energy in pile impact impulses is at frequencies below approximately 2000 Hz with most occurring below 1000 Hz (Laughlin 2006; Reyff 2008; Reyff 2012). Pressure levels from 190 to 220 dB re 1 μ Pa were reported for piles of different sizes in a number of studies (NMFS 2006). The majority of the sound energy associated with pile driving is in the low frequency range ($< 1,000$ Hz) (Illingworth and Rodkin Inc. 2001; Reyff 2003; Illingworth and Rodkin Inc. 2004). Impact pile driving occurs over small spatial and temporal scales and produces high-intensity, low-frequency, impulsive sounds with high peak pressures that can be detected by mammals, sea turtles and other marine species (Dow Piniak et al. 2012). The expected type of injury to sea turtles and marine mammals is caused by pressure wave damage to hair cells, ear canals, or ear drums as these structures compress and expand with passage of the wave. Vibratory pile driving produces a continuous sound with peak pressures lower than those observed in impulses generated by impact pile driving (Popper et al. 2014).

5.2.5 Oil and Gas

Oil and gas operations on the Outer Continental Shelf (OCS) in the Gulf of America that have been ongoing for decades involve a variety of activities that may adversely affect ESA-listed species in the action area. These activities and resulting impacts include vessels making supply deliveries, drilling operations, seismic surveys, fluid spills, oil spills and response, and oil platform removals. As technology has advanced over the past several decades, oil exploration and development has moved and will continue to move further offshore into deeper waters (Murawski et al. 2020).

BOEM administers the Outer Continental Shelf Lands Act (OCSLA) and authorizes the exploration and development of wells in Gulf leases. The sale of OCS leases in the Gulf of America and the resulting exploration and development of these leases for oil and natural gas resources has affected the status of ESA-listed species in the action area. As discussed above (Section 5.2.2), seismic exploration is an integral part of oil and gas discovery, development, and production in the Gulf of America. Year-round noise generated by oil and gas vessels and airguns use for seismic surveys has permanently changed the marine soundscape in the Gulf of America.

The development of wells often involves additional activities such as the installation of platforms, pipelines, and other infrastructure. Once operational, a platform will generate a variety of wastes including effluents and emissions. BOEM requires that oil and gas structures must be removed from the sea floor within one year of lease termination. Many of these structures are removed by explosively severing the underwater supportive elements, which produces a shock wave that kills, injures, or disrupts marine life in the blast radius (Gitschlag et al. 1997). An underwater explosion is composed of an initial shock wave, followed by a succession of oscillating bubble pulses. A shock wave is a compression wave that expands radially out from the detonation point of an explosion. The direct shock wave results in the peak shock pressure

(compression) and the reflected wave at the air-water surface produces negative pressure (expansion). Explosions are described by metrics such as amplitude, energy and time-space characteristics of the pressure wave (Popper et al. 2014). Explosive detonations and their impacts on ESA-listed species are discussed in more detail this opinion (see Sections 2.4.2, 6.1.1, 6.2.1, and 6.3.1).

5.2.6 Oil Spills and Natural Seeps

Oil spills are accidental and unpredictable events that remain a significant threat to marine ecosystems, including ESA-listed species, in the Gulf of America due to the large amount of extraction and refining activity in the region. There are approximately 4,000 oil and gas structures in the northern Gulf of America, 90% of which are off Louisiana and Texas (USN 2009). Oil spills can occur at any number of points during the exploration, development, production, and transport of oil.

The largest spill within the action area occurred on April 20, 2010, the semi-submersible drilling rig Deep Water Horizon (DWH) experienced an explosion and fire while working on an exploratory well approximately 50 miles offshore Louisiana (Figure 52). The rig subsequently sank and oil and natural gas began leaking into the surrounding waters of the Gulf of America. Oil flowed for 86 days until the well was capped on July 15, 2010. Although estimates vary, roughly 4.1 million barrels of oil were released directly into the Gulf of America (USDOJ 2012). In addition, approximately 1.84 million gallons of chemical dispersant were applied both subsurface and on the surface to attempt to break down the oil.

During surveys in offshore oiled areas, of the 520 sea turtles captured, 394 showed signs of being oiled (Witherington et al. 2012b). A large majority of these were juveniles, mostly green (311) and Kemp's ridley sea turtles (451). An additional 78 adult or subadult loggerheads were observed (Witherington et al. 2012b). Captures of sea turtles along the Louisiana's Chandeleur Islands in association with emergency sand berm construction resulted in 185 loggerheads, eight Kemp's ridley, and a single green sea turtle being captured and relocated (Dickerson and Bargo 2012). In addition, 274 nests along the Florida panhandle were relocated that ultimately produced 14,700 hatchlings, but also had roughly 2% mortality associated with the translocation (MacPherson et al. 2012). Females that laid these nests continued to forage in the area, which was exposed to the footprint of the oil spill (Hart et al. 2014). Large areas of *Sargassum* were affected, with some heavily oiled or dispersant-coated *Sargassum* sinking and other areas accumulating oil where sea turtles could inhale, ingest, or contact it (USDOJ 2012; Powers et al. 2013). Of 574 sea turtles observed in these *Sargassum* areas, 464 were oiled (USDOJ 2012).

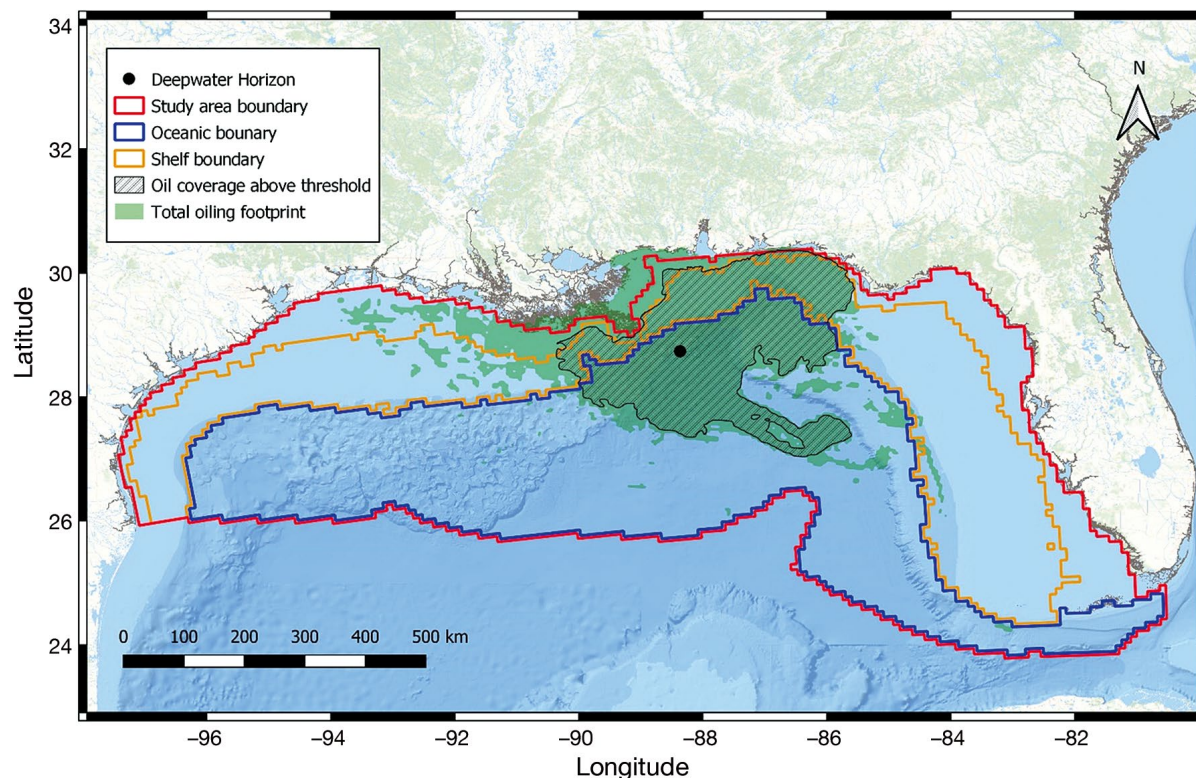


Figure 52. Map of the Gulf of America Showing the Location of the Deepwater Horizon Oil Rig and the Area Affected by the Oil Spill (Marques et al. 2023)

Oil released into the marine environment contains aromatic organic chemicals known to be toxic to a variety of marine life (Yender et al. 2002). Oil spills can impact wildlife directly through three primary pathways: (1) ingestion—when animals swallow oil particles directly or consume prey items that have been exposed to oil, (2) absorption—when animals come into direct contact with oil, and (3) inhalation—when animals breathe volatile organics released from oil or from “dispersants” applied by response teams in an effort to increase the rate of degradation of the oil in seawater. Direct exposure to oil can cause acute damage including skin, eye, and respiratory irritation, reduced respiration, burns to mucous membranes such as the mouth and eyes, diarrhea, gastrointestinal ulcers and bleeding, poor digestion, anemia, reduced immune response, damage to kidneys or liver, cessation of salt gland function, reproductive failure, and death (Vargo et al. 1986). Nearshore spills or large offshore spills that reach shore can oil beaches on which sea turtles lay their eggs, causing birth defects or mortality in the nests (NOAA 2003; NOAA 2010). Disruption of other essential behaviors, such as breeding, communication, and feeding may also occur. The loss of invertebrate communities due to oiling or oil toxicity would also decrease prey availability for hawksbill, Kemp’s ridley, and loggerhead sea turtles (NOAA 2003). Sea turtles species which commonly forage on crustaceans and mollusks may be vulnerable to oil ingestion due to oil adhering to the shells of these prey and the tendency for these organisms to bioaccumulate toxins found in oil (NOAA 2003). Seagrass beds may be particularly susceptible to oiling as oil contacts grass blades and sticks to them, hampering photosynthesis and gas

exchange (Wolfe et al. 1988). If spill cleanup is attempted, mechanical damage to seagrass can result in further injury and long-term scarring. Loss of seagrass due to oiling would be important to green sea turtles, as this is a significant component of their diets (NOAA 2003). Sea turtles are known to ingest and attempt to ingest tar balls, which can block their digestive systems, impairing foraging or digestion and potentially causing death (NOAA 2003).

Several studies have shown crude oil can be harmful to larval stages of fish. Macondo crude oil was shown to cause significant defects in embryonic and larval development of zebrafish (de Soysa et al. 2012). DWH oil-exposed samples of embryonic mahi-mahi resulted in cardiotoxicity, evident from pericardial edema and reduced atrial contractility (Esbaugh et al. 2016). Similar results were also found for developing hearts of large predatory fish (Incardona et al. 2014) and long-term effects of embryonic exposure may cause future declines in populations (Incardona et al. 2015).

The unprecedented DWH oil spill and associated response activities (e.g., skimming, burning, and application of dispersants) resulted in severe adverse effects on ESA-listed species and changed the baseline for the Gulf of America ecosystem. As discussed in Section 4.2.1, Rice's whales were one of the most impacted marine mammal species affected by DWH oil spill (DWHTrustees 2016). Frasier et al. (2024a) documented density declines for seven (out of eight monitored) odontocete species in the northeastern Gulf of America in the decade after the DWH oil spill, including a 31% decline in sperm whales. Based on a spatial density modeling approach, Marques et al. (2023) reported that the magnitude of population injury from the DWH oil spill varied across cetacean species and taxonomic units, with the greatest impact on spinner and striped dolphins, sperm whales, and *Kogia sp.*, all of which had estimated decreases of over 5% of the stock at their maximum decline point.

Following Hurricane Ida's landfall in the Gulf of America region in September 2021, NOAA responded to 282 individual discharges of oil from wells, pipelines, and vessels caused by storm damage (NOAA 2021). On December 24, 2022, a pipeline failure at a crude oil terminal in Corpus Christi Bay, Texas, released around 14,000 gallons of light crude oil, with recorded impacts to green sea turtles (NOAA 2024). On November 16, 2023, a pipeline crude oil leak off the coast of Louisiana was reported to NOAA and other Federal and state agencies, with an estimated 1.1 million gallons at risk of spill and an observed slick over 40 miles in length (NOAA 2023). Part of the reported leak overlapped with habitat for the Rice's whale.

In addition to accidental spills, leakage from operating and decommissioned sites can pose an ongoing threat to the ocean ecosystem and ESA-listed species by potentially introducing hydrocarbons and other polluting dispersants to surrounding waters. A study from 2023 estimates that as of 2020, a total of 7,188 inactive wells or inactive leases in Federal waters of the Gulf of America had not been permanently plugged (Agerton et al. 2023). Deteriorating structures from delayed decommissioning can become more vulnerable to damage and destruction from storms that are increasingly frequent due to changing environmental conditions, which increases the risk of oil spills and harmful debris into species' habitat (GAO 2024).

In addition to oil spills resulting from anthropogenic activities, oil can also be introduced into the marine ecosystem through natural seeps. Natural seeps provide the largest petroleum input to the offshore Gulf of America, about 95% of the total. Mitchell et al. (1999) estimated a range of 280,000 to 700,000 barrels (bbl) per year (40,000 to 100,000 tonnes per year), with an average of 490,000 bbl (70,000 tonnes) for the northern Gulf of America, excluding the Bay of Campeche. Using this estimate and assuming seep scales are proportional to surface area, the (NRC 2003) estimated annual seepage for the entire Gulf of America at about 980,000 bbl (140,000 tonnes) per year, or about three times the estimated amount of oil spilled by the 1989 Exxon Valdez event (about 270,000 bbl) (SteynSteyn 2010) or a quarter of the amount released by the DWH event (4.9 million bbl of oil) (Lubchenco and Sutley 2010). As seepage is a natural occurrence, the rate of approximately 980,000 bbl (140,000 tonnes) per year is expected to remain unchanged into the foreseeable future.

5.3 Dredging

Riverine, nearshore, and offshore coastal areas are often dredged to support commercial shipping, recreational boating, construction of infrastructure, and marine mining. Dredging in spawning and nursery grounds modifies habitat quality, and limits the extent of available habitat in some rivers where anadromous fish habitat has already been impacted by the presence of dams. Dredging and filling operations impact important habitat features of Atlantic sturgeon as they disturb benthic fauna, eliminate deep holes, and alter rock substrates (Smith and Clugston 1997). Dredging operations may also pose risks to anadromous fish species by destroying or adversely modifying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. As benthic omnivores, sturgeon are particularly sensitive to modifications of the benthos that affect the quality, quantity and availability of prey species. Nellis et al. (2007) documented that dredge spoil drifted 12 km downstream over a ten-year period in the Saint Lawrence River, and that those spoils have significantly less macrobenthic biomass compared to control sites. Hatin et al. (2007) reported avoidance behavior by Atlantic sturgeon during dredging operations and McQuinn and Nellis (2007) found that Atlantic sturgeon were substrate dependent and avoided dredge spoil dumping grounds. Indirect effects of dredging related to water quality include changes in DO and salinity gradients in and around dredged channels (Jenkins et al. 1993; Secor and Niklitschek 2001; Campbell and Goodman 2004). Adult shortnose sturgeon can tolerate at least short periods of low DO and high salinities, but juveniles are less tolerant of these conditions in laboratory studies. Collins et al. (2000) concluded harbor modifications in the lower Savannah River have altered hydrographic conditions for juvenile sturgeon by extending high salinities and low DO upriver.

In addition to indirect impacts, hydraulic dredging can directly harm sturgeon and sea turtles by lethally entraining them up through the dredge drag-arms and impeller pumps. Large marine animals that are entrained in hydraulic dredges rarely survive the encounter. Hopper dredges, in particular, are capable of moving relatively quickly compared to sea turtles and fish which can be overtaken and entrained by the suction draghead of the advancing dredge. A total of 609

incidental takes (lethal or sublethal interactions) of sea turtles have been documented from hopper dredging activities in the southeastern U.S. from 1980 through 2006 (Dickerson et al. 2007). Dickerson (2006) reported 15 Atlantic sturgeon taken in dredging activities conducted by the United States Corps of Engineers from 1990 to 2010, most captured by hopper dredge. Notably, these reports include only those trips when an observer was on board to document capture. Atlantic sturgeon have also been taken in both hydraulic pipeline and bucket-and-barge operations in the Cape Fear River, North Carolina (Moser and Ross 1995), and by mechanical dredges in the Delaware River (Hastings 1983).

Reductions in entrainment rates for sea turtles have been achieved through gear modifications, operational changes, time-area restrictions, and the capture and relocation of sea turtles away from dredge sites (Dickerson et al. 2007). Dickerson et al. (2007) studied the effectiveness of sea turtle relocation trawling in reducing the incidental take of sea turtles in hopper dredge operations. They found that relocation trawling can be an effective management option provided that a substantial amount of trawling effort is conducted either at the onset of dredging or early in the project.

5.4 Pollution

Within the action area, pollution poses a threat to ESA-listed species. Pollution can come in the form of marine debris, pesticides, contaminants, and hydrocarbons. Anthropogenic sources of marine pollution, while difficult to attribute to a specific Federal, state, local, or private action, may affect ESA-listed species in the action area. Sources of pollutants in the action area include atmospheric loading of pollutants (e.g., PCBs); storm water runoff from coastal towns, cities, and villages; runoff into rivers emptying into bays; groundwater discharges; sewage treatment plant effluents; and oil spills, which were discussed in Section 5.3.1. Degraded water quality from point and nonpoint sources can impact ESA-listed species. Run-off can introduce pesticides, herbicides, and other contaminants into the system on which these species depend. Contaminants could degrade habitat if pollution and other factors reduce the food available to marine animals.

5.4.1 Contaminants and Pesticides

Coastal habitats are often in close proximity to major sources of pollutants and heavy metals, which make their way into the marine environment from industrial, domestic and agricultural sources. Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. These contaminants bioaccumulate through the food chain and can result in lethal and sublethal effects on marine organisms. Polycyclic aromatic hydrocarbons (PAHs) represent another group of organic compounds that can result in adverse effects on marine species. Anthropogenic sources of PAHs include crude oil (see *Oil and Gas*), fumes, vehicle exhaust, coal, organic solvents, and wildfires. Exposure may be continual, associated with run-off from impervious cover in developed coastal regions, or natural seeps that produce low-level but steady exposure. Acute events such as oil spills may produce pulses of more significant exposure. Depending on the route of exposure (inhalation/aspiration, ingestion, direct dermal contact), PAHs can produce a

broad range of health effects including lung disease, disruption of the hypothalamic pituitary-adrenal (HPA) axis, and altered immune response (National Academies of Sciences and Medicine 2016). Although PAHs are more rapidly metabolized and do not accumulate as is the case with POPs, the toxic effects (lung disease, HPA-axis damage) may be long-lasting and initiate chronic disease conditions.

Contaminants can be carried long distances from terrestrial or nearshore sources and ultimately accumulate in offshore pelagic environments (USCOP 2004). For example, the Gulf of America portion of the action area is a major sink for pollution from a variety of marine and terrestrial sources, which ultimately can interfere with ecosystem health, particularly that of ESA-listed species and their habitats. The Mississippi River drains 80% of the U.S. cropland (including the fertilizers, pesticides, herbicides, and other contaminants that are applied to it) and discharges into the Gulf of America (MMS 1998).

North Atlantic right whales, like many marine mammals, are exposed to numerous toxins in their environment, many of which are introduced by anthropogenic activities. Levels of chromium in North Atlantic right whale tissues are sufficient to be mutagenic and cause cell death in lung, skin, or testicular cells and are a concern for the species' recovery (Wise et al. 2008; Chen et al. 2009). The organochlorines DDT, dichlorodiphenyldichloroethylene (DDE), PCBs, dieldrin, chlordane, and heptachlor epoxide have been isolated from blubber samples and reported concentrations may underestimate actual levels (Woodley et al. 1991). Mean PCB levels in North Atlantic right whales are greater than any other baleen whale species thus far measured, although less than one-quarter of the levels measured in harbor porpoises (Van Scheppingen et al. 1996; Gauthier et al. 1997). Flame retardants such as Polybrominated diphenyl ethers (PBDEs; known to be carcinogenic) have also been measured in North Atlantic right whales (Montie et al. 2010).

Heavy metal pollution poses an increasing threat to marine life globally. Due to bioaccumulation, the risks of heavy metal pollution are particularly acute for large species at high trophic levels although this will vary based on a species' diet and foraging location (Chan et al. 2025). A variety of heavy metals have been found in sea turtles tissues in levels that increase with sea turtle size. These include arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc, (Godley et al. 1999; Fujihara et al. 2003; Storelli et al. 2008; Barbieri 2009; García-Fernández et al. 2009). Cadmium has been found in leatherbacks at the highest concentration compared to any other marine vertebrate (Gordon et al. 1998). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996). Arsenic has been found to be very high in green turtle eggs (Van de Merwe et al. 2009). In a comparison of heavy metal concentrations across sea turtle species, Chan et al. (2025) found that loggerhead turtles had the least variability in metal heavy concentrations, potentially driven by a generalist foraging strategy, relative to green and Kemp's ridley turtles.

All three species had concentrations of arsenic and cadmium near values considered toxic in vertebrates with loggerhead turtles having the highest concentrations (Chan et al. 2025).

Sea turtle tissues have been found to contain organochlorines, including chlorobiphenyl, chlordane, lindane, endrin, endosulfan, dieldrin, perfluorooctane sulfonate, perfluorooctanoic acid, DDT, and PCB (Gardner et al. 2003; Keller et al. 2005; Alava et al. 2006; Storelli et al. 2007; Oros et al. 2009). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (Davenport et al. 1990; Oros et al. 2009). Levels of PCBs found in green sea turtle eggs are considered far higher than what is fit for human consumption (Van de Merwe et al. 2009).

Several studies have reported correlations between organochlorine concentration level and indicators of sea turtle health or fitness. Organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller et al. 2006; Oros et al. 2009). Accumulation of these contaminants can also lead to deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation. Balazs (1991) suggested that environmental contaminants are a possible factor contributing to the development of the viral disease fibropapillomatosis in sea turtles by reducing immune function. Day et al. (2007) investigated mercury toxicity in loggerhead sea turtles by examining trends between blood mercury concentrations and various health parameters. They concluded that subtle negative impacts of mercury on sea turtle immune function are possible at concentrations observed in the wild. Keller et al. (2004) investigated the possible health effects of organochlorine contaminants, such PCBs and pesticides on loggerhead sea turtles. Although concentrations were relatively low compared with other species, they found significant correlations between organochlorine contaminants levels and health indicators for a wide variety of biologic functions, including immunity and homeostasis of proteins, carbohydrates, and ions.

The life histories of sturgeon species (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose them to long-term, repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979). Shortnose sturgeon collected from the Delaware and Kennebec Rivers had total toxicity equivalent concentrations of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, PCBs, DDE, aluminum, cadmium, and copper all above adverse effect concentration levels reported in the literature (Brundage III 2008). Dioxin and furans were detected in ovarian tissue from shortnose sturgeon caught in the Sampit River/Winyah Bay system (South Carolina).

Heavy metals and organochlorine compounds accumulate in sturgeon tissue, but their long-term effects are not well studied (Ruelle and Keenlyne 1993). High levels of contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Giesy et al. 1986; Cameron et al. 1992; Billsson 1998; Hammerschmidt et al. 2002), reduced survival of larval fish (Willford et al. 1981; McCauley et al. 2015), delayed maturity and

posterior malformations (Billsson 1998). Pesticide exposure in fish may affect anti-predator and homing behavior, reproductive function, physiological maturity, swimming speed, and distance (Beauvais et al. 2000; Scholz et al. 2000; Waring and Moore 2004). Sensitivity to environmental contaminants also varies by life stage. Early life stages of fish appear to be more susceptible to environmental and pollutant stress than older life stages. (Rosenthal and Alderdice 1976). Early life stage Atlantic and shortnose sturgeon are vulnerable to PCB and Tetrachlorodibenzo-p-dioxin (TCDD) toxicities of less than 0.1 parts per billion (Chambers et al. 2012). Increased doses of PCBs and TCDD have been correlated with reduced physical development of Atlantic sturgeon larvae, including reductions in head size, body size, eye development and the quantity of yolk reserves (Chambers et al. 2012). Juvenile shortnose sturgeon raised for 28 days in North Carolina's Roanoke River had a 9% survival rate compared to a 64% survival rate at non-riverine control sites (Cope et al. 2011). The reduced survival rate could not be correlated with contaminants, but significant quantities of retene, a paper mill by-product with dioxin-like effects on early life stage fish, were detected in the river (Cope et al. 2011).

Dwyer et al. (2005) compared the relative sensitivities of common surrogate species used in contaminant studies to 17 ESA-listed species including Atlantic sturgeons. The study examined 96-hour acute water exposures using early life stages where mortality is an endpoint. The chemicals tested were carbaryl, copper, 4-nonphenol, pentachlorophenol and permethrin. Of the ESA-listed species, Atlantic sturgeon were ranked the most sensitive species tested for four of the five chemicals (Atlantic and shortnose sturgeon were found to be equally sensitive to permethrin). Additionally, a study examining the effects of coal tar, a byproduct of the process of destructive distillation of bituminous coal, indicated that components of coal tar are toxic to shortnose sturgeon embryos and larvae in whole sediment flow-through and coal tar elutriate static renewal (Kocan et al. 1993).

Evaluations of water and sediment quality in Gulf sturgeon habitat on the northern Gulf of America coast have consistently shown elevated pollutant loading (USFWS and NMFS 2022). Widespread contamination has also been documented throughout the overwintering feeding habitat of the Gulf sturgeon. Although the specific effects of these widely varied pollutants on sturgeon in their various life stages are not clearly understood, there is ample evidence summarized below to show potential harmful effects to Gulf sturgeon and their habitat (USFWS and NMFS 2022).

Toxicity data are not available for scalloped hammerhead sharks or Nassau grouper, but there have been studies using saltwater and estuarine fish species to determine the toxicity of and response to certain metals. Results of these studies suggest that chronic exposure to copper could potentially lead to developmental effects to Nassau grouper and unusual behavior in juveniles. Contaminants such as heavy metals could reach nearshore waters from coastal development, affecting Nassau grouper, scalloped hammerhead sharks, and ESA-listed corals.

Limited data are available for ESA-listed corals related to exposure and toxicity thresholds for things like heavy metals. Exposure data that are available, such as from studies using

mountainous star coral indicate that chronic exposure to certain concentrations of copper result in effects to embryo development (Bielmyer et al. 2010). Water pollution can inflict additional stress on corals (Hughes and Connell 1999). Several studies suggest a direct link between declining water quality from increased runoff, sedimentation and pollutants, which can be a byproduct of coastal development or other human activity, and coral reef health and bleaching (Ennis et al. 2016; Gailani et al. 2016; Nelson et al. 2016). For example, toxicants such as oxybenzone, zinc and titanium oxide found in sunscreens and personal beauty products have been shown to induce severe and rapid coral bleaching due to the alteration of the symbiosis between coral and zooxanthellae (Downs et al. 2016; Corinaldesi et al. 2018) and the concentrations of these contaminants in nearshore waters increases with increased tourism development, as well as increased vessel operation and wastewater discharges associated with coastal development.

5.4.2 Nutrient Loading and Algal Blooms

Industrial and municipal activities can result in the discharge of large quantities of nutrients into coastal waters. Excessive nutrient enrichment results in eutrophication, a condition associated with degraded water quality, algal blooms (including harmful algal blooms), oxygen depletion, loss of seagrass and coral reef habitat, and in some instances the formation of hypoxic “dead zones” (USCOP 2004). Hypoxia (low DO concentration) occurs when waters become overloaded with nutrients such as nitrogen and phosphorus, which enter oceans from agricultural runoff, sewage treatment plants, bilge water, atmospheric deposition, and other sources. An overabundance of nutrients can stimulate algal blooms resulting in a rapid expansion of microscopic algae (phytoplankton). When excess nutrients are consumed, the algae population dies off and the remains are consumed by bacteria. Bacterial consumption decreases the DO level in the water which may result in mortality of fish and crustaceans, reduced benthic and demersal organism abundance, reduced biomass and species richness, and abandonment of habitat to sufficiently oxygenated areas (Craig et al. 2001; Rabalais et al. 2002). Higher trophic-level species (e.g. sea turtles and marine mammals) may be impacted by the reduction of available prey as a result of hypoxic conditions. For example, high nutrient loads from the Mississippi River create a massive hypoxic “dead zone” in Northern Gulf of America each year. This hypoxic event occurs annually from as early as February to as late as October, spanning from the Mississippi River Delta to Galveston, Texas. In 2024, NOAA estimated that the Gulf of America dead zone covered over 6,700 square miles, an area about the size of New Jersey.

Marine algal toxins are produced by unicellular algae that are often present at low concentrations but that may proliferate to form dense concentrations under certain environmental conditions (National Academies of Sciences and Medicine 2016). When high cell concentrations form, the toxins that they produce can harm marine life, which is referred to as a harmful algal bloom (HAB). Marine mammals can be exposed to HAB toxins directly by inhalation or indirectly through food web transfer, and these toxins can cause severe neurotoxic effects (Van Dolah 2005). Mortality and morbidity related to HAB toxins have been increasingly reported over the

past several decades, and biotoxigenesis has been a primary contributor to large scale die-offs across marine mammal taxa (Van Dolah 2005; Simeone et al. 2015). Domoic acid has also been detected in tissues of marine mammals along the southeast U.S. coast (Twiner et al. 2011), but perhaps of greater concern in this area are the brevetoxins produced by Gulf of America red tides. Brevetoxin has been implicated in multiple die-offs involving common bottlenose dolphins, as well as the endangered Florida manatee (Flewelling et al. 2005; Twiner et al. 2012; Simeone et al. 2015). Capper et al. (2013) found that both sea turtles and manatees were exposed to multiple HAB toxins (okadaic acid, brevetoxins, saxitoxins, and likely others) in Florida. A recent survey of the peer reviewed literature on marine mammal diseases and reports of marine mammal mass mortality events suggests an increase in the frequency of marine mammal die-offs resulting from exposure to harmful algal blooms over the past 40 years (Gulland and Hall 2007). Results from Vilas et al. (2023) suggest that severe red tide fisheries impacts have occurred on the West Florida Shelf, located in the eastern Gulf of America, at the ecosystem, community, and population levels in terms of biomass, catch, and productivity. Blooms of the toxic dinoflagellate *Karenia brevis* occur frequently on the west coast of Florida, killing fish and other marine life. The 2018 *Karenia brevis* harmful algal bloom experienced along the west coast of Florida was the worst red tide occurrence there since 2005 (Liu et al. 2022).

5.4.3 Marine Debris

Marine debris has become a widespread threat for a wide range of marine species that are increasingly exposed to it on a global scale. Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources (Gallo et al. 2018). Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment (Watters et al. 2010). Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it, which can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality for ESA-listed species in the action area (Derraik 2002; Gall and Thompson 2015).

The most common impacts of marine debris are associated with ingestion or entanglement and both types of interactions can cause the injury or death of animals of many different species. Ingestion occurs when debris items are intentionally or accidentally eaten (e.g. through predation on already contaminated organisms or by filter feeding activity, in the case of large filter feeding marine organisms, such as whales) and enter in the digestive tract. Ingested debris can damage the digestive system and plastic ingestion can also facilitate the transfer of lipophilic chemicals (especially POPs—persistent organic pollutants) into the animal's body. Plastic is the most abundant material type worldwide, accounting for more than 80% of all marine debris (Poeta et al. 2017). An estimated 4 to 12 metric tons of plastic enter the oceans annually (Jambeck et al. 2015). Lestrade and Hernandez (2023) found concentrations of microdebris were 180 times higher in holopelagic *Sargassum* in the Gulf of America than in surrounding open water habitat,

suggesting *Sargassum* acts as a "sink" for microdebris. They also found microdebris was found in the guts of juvenile fishes that use *Sargassum* as nursery habitat, which may impact fish health and condition.

An estimated 640,000 tons of fishing gear is lost, abandoned, or discarded at sea each year throughout the world's oceans (Macfadyen et al. 2009). These "ghost nets" drift in the ocean and can fish unattended for decades (ghost fishing), killing large numbers of marine animals through entanglement.

Marine debris is a significant concern for ESA-listed sea turtles in particular because the same processes that draw sea turtles' buoyant food sources also accumulate large volumes of marine debris, such as plastics and lost fishing gear, in ocean gyres (Carr 1987). The initial developmental stages of all sea turtle species are spent in the open sea. During this time both juvenile sea turtles and their buoyant food are drawn by advection into fronts (convergences, rips, and driftlines). The same process accumulates large volumes of marine debris, such as plastics and lost fishing gear, in ocean gyres (Carr 1987).

Ingestion of plastic debris can block the digestive tract which can cause turtle mortality as well as sublethal effects including dietary dilution, reduced fitness, and absorption of toxic compounds (Lutcavage et al. 1997; Laist et al. 1999). It is thought that sea turtles eat plastic because it closely resembles jellyfish, a common natural prey item (Schuyler 2014). Schuyler et al. (2016) estimates that 52% of sea turtles globally have ingested plastic debris. Schuyler et al. (2016) synthesized the factors influencing debris ingestion by sea turtles into a global risk model, taking into account the area where turtles are likely to live, their life history stage, the distribution of debris, the time scale, and the distance from stranding location. They found that oceanic life stage sea turtles are at the highest risk of debris ingestion. Based on this model, olive ridley turtles are the most at-risk species; green, loggerhead, and leatherback turtles were also found to be at a high and increasing risk from plastic ingestion (Schuyler 2014). The regions of highest risk to global turtle populations are off the east coasts of the U.S., Australia, and South Africa; the east Indian Ocean, and Southeast Asia.

In addition to ingestion risks, sea turtles can also become entangled in marine debris such as fishing nets, monofilament line, and fish-aggregating devices (NRC 1990; Lutcavage et al. 1997; Laist et al. 1999). Turtles are particularly vulnerable to "ghost fishing" nets due to their tendency to use floating objects for shelter and as foraging stations (Kiessling 2003; Dagorn et al. 2013).

From 2017 to 2021, data from field research and the public in Florida documented 176 smalltooth sawfish that were entangled, injured, or killed by debris or human interactions (Yakich et al. 2024). While entanglements in fishing gear (e.g., trawls, fishing tackle) remain the most frequent threat (see Section 5.7), interactions with household items have increased. Since 2017, 30 sawfish were reported with encircling debris (e.g., monofilament loops, rubber bands, ball bungee cords) around anterior parts of their bodies (Yakich et al. 2024).

Marine mammals are also particularly susceptible to the threats associated with marine debris, and many cases of ingestion and entanglement have been reported around the world (Poeta et al. 2017). Given the limited knowledge about the impacts of marine debris on marine mammals, it is difficult to determine the extent of the threats that marine debris poses to marine mammals. Over half of the cetacean species (including sperm whales) are known to ingest marine debris (mostly plastic), with up to 31% of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22% of individuals found stranded on shorelines (Baulch and Perry 2014). Entanglement records have clearly been attributed to marine debris for humpback, right, and sperm whales, among others (Laist 1997; Baulch and Perry 2012; NOAA 2014a). Baulch and Perry (2014) found that the proportion of cetacean species ingesting debris or becoming entangled in debris is increasing. Based on stranding data, they found that recorded rates of ingestion have increased by a factor of 1.9 and rates of entanglement have increased by a factor of 6.5 over the last 40 years (1970 to 2010). Entanglement of large whales in fishing gear is discussed in Section 5.8.

Ingestion of marine debris can also have fatal consequences for large whales. For example in 2008, two male sperm whales stranded along the northern California coast with large amounts of fishing net scraps, rope, and other plastic debris in their stomachs. One animal had a ruptured stomach, the other was emaciated, and gastric impaction was suspected as the cause of both deaths (Jacobsen et al. 2010). de Stephanis et al. (2013) also describe a case of mortality of a sperm whale related to the ingestion of large amounts of marine debris in the Mediterranean Sea. ESA-listed marine mammals in the action area are known to be negatively impacted by marine debris. For example, a sei whale stranded and died in the James River, VA after ingesting a plastic DVD case; this ingestion of plastic debris was the proximate cause of death (Hayes et al. 2021). A Rice's whale stranded in 2019 was found with a hard, sharp piece of ingested plastic, which was believed to contribute to the stranding and ultimate death of the animal (Rosel et al. 2021).

Marine debris may also impact coral reef ecosystems. For example, Chiappone et al. (2002) conducted surveys of the Florida Keys and documented marine debris entanglement in reef areas. The authors documented damage from marine debris on coral reef habitat, including damage to scleractinian corals (likely inclusive of ESA-listed corals such as elkhorn and staghorn coral).

5.5 Offshore Wind Development

The action area includes a number of areas that have been leased by BOEM for offshore wind development or that are being considered for lease issuance; additionally, the action area overlaps with the action area identified in a number of biological opinions issued for offshore wind projects. In the context of offshore wind development, past and present impacts in the action area include effects of pre-construction surveys to support site characterization, site assessment, and data collection to support the development of Construction and Operations Plans (COPs), as well as ongoing effects of construction of the South Fork (off of Long Island, New York) and Vineyard Wind 1 (off of Cape Cod, Massachusetts) projects. To date, NMFS has

completed section 7 consultation to consider the effects of construction, operation, and decommissioning of multiple commercial scale offshore wind projects in the action area (Vineyard Wind 1, South Fork Wind, Revolution Wind, Ocean Wind 1, Empire Wind). We have also completed ESA section 7 consultation on two smaller scale offshore wind projects that occur in the action area, the Block Island (off of Rhode Island) project, and Dominion's Coastal Virginia Offshore Wind Demonstration Project. Complete information on the assessment of effects of these projects is found in their respective biological opinions (Block Island - NMFS 2015a; CVOW - pilot project NMFS 2016b; South Fork Wind - NMFS 2021a; Vineyard Wind 1 - NMFS 2021c; Ocean Wind 1 - NMFS 2023a; Revolution Wind - NMFS 2023g; Empire Wind - NMFS 2023f).

A number of geotechnical and geophysical surveys to support wind farm leasing have occurred and will continue to occur in the action area. Additionally, data collection buoys have been installed. Effects of these activities on ESA-listed species in the action area are related to potential exposure to noise associated with survey equipment, survey vessels, and habitat impacts. Given the characteristics of the noise associated with survey equipment and the use of best management practices to limit exposure of listed species, including protected species observers, effects of survey noise on ESA-listed species have been determined in previous consultations to be extremely unlikely or insignificant. There is no information that indicates that the noise sources used for these surveys has the potential to result in injury, including hearing impairment, or mortality of any ESA-listed species in the action area. Similarly, we have not anticipated any adverse effects to habitats or prey and do not anticipate any ESA-listed species to be struck by survey vessels; risk is reduced by the slow speeds that survey vessels operate at, the use of observers or lookouts, and incorporation of vessel strike avoidance measures.

Surveys to obtain data on fisheries resources have been undertaken in the larger action area to support offshore wind development. Some gear types used, including gillnet, trawl, and trap/pot, can entangle or capture ESA-listed sea turtles, fish, and whales. Risk can be reduced through avoiding certain times/areas, minimizing soak and tow times, and using gear designed to limit entanglement or reduce the potential for serious injury or mortality.

5.6 Fisheries Directed Harvest and Bycatch

Past directed commercial fisheries contributed to the steady decline in the population abundance of many populations of ESA-listed sturgeon and salmon. Between 1890 and 1905, Atlantic sturgeon populations were drastically reduced due to overfishing for sale of meat and caviar. Harvest records indicate that fisheries for sturgeon were conducted in every major coastal river along the Atlantic coast at one time, with fishing effort concentrated during spawning migrations (Smith 1985). Approximately 3,350 metric tons (7.4 million lbs) of sturgeon (Atlantic and shortnose combined) were caught in 1890 (Smith and Clugston 1997). The sturgeon fishery during the early years (1870 to 1920) was concentrated in the Delaware River and Chesapeake Bay systems. During the 1970s and 1980s sturgeon fishing effort shifted to the South Atlantic, which accounted for nearly 80% of total U.S. landings (64 metric tons). Prompted by research on

juvenile production between 1985 and 1995 (Peterson et al. 2000), the Atlantic sturgeon fishery was closed by the ASMFC in 1998 when a coast-wide fishing moratorium was imposed for 20 to 40 years, or at least until 20 year classes of mature female Atlantic sturgeon were present (ASMFC 2017). NMFS followed this action by closing the EEZ to Atlantic sturgeon take in 1999. Poaching of Atlantic sturgeon continues and is a potentially significant threat to the species, but the present extent and magnitude of such activity is largely unknown.

Although directed fishing for Atlantic sturgeon is prohibited under the ESA, large numbers are still captured as “bycatch” in fishing operations targeting other species. The available bycatch data for federally managed fisheries indicate that sink gillnets and bottom otter trawl gear pose the greatest risk to Atlantic sturgeon; although, Atlantic sturgeon are also caught by hook and line, fyke nets, pound nets, drift gillnets and crab pots (ASMFC 2017). Mortality in both commercial and recreational fisheries has been, and still is, the primary threat responsible for the decline in smalltooth sawfish abundance (Brame et al. 2019).

Commercial fisheries bycatch also represents a significant threat to sea turtles throughout the action area, as sea turtles are highly vulnerable to incidental capture in many fisheries gears including tangle nets, trawls and longlines. Sea turtles are vulnerable to interactions with fisheries occurring off the U.S. South Atlantic coast, particularly the Atlantic shrimp trawl fishery. Finkbeiner et al. (2011) compiled cumulative estimates of sea turtle bycatch across fisheries of the U.S. between 1990 and 2007, before and after implementation of fisheries-specific bycatch mitigation measures. Pre- and post-regulatory strata were identified for each fishery based on the first year a sea turtle bycatch mitigation strategy was mandated. For the Atlantic region, an annual mean of 345,800 sea turtle interactions and 70,700 deaths was estimated for the pre-regulatory strata across all fisheries included in this study. By comparison, an annual mean of 137,700 sea turtle interactions and 4,500 deaths was estimated for the post-regulatory strata.

Leatherback sea turtles are particularly vulnerable to entanglement in vertical lines. Since 2005, 379 leatherbacks have been reported entangled in vertical lines in the Northeast Region. In response to high numbers of leatherback sea turtles found entangled in the vertical lines of fixed gear in the Northeast Region, NMFS established the Northeast Atlantic Coast Sea Turtle Disentanglement Network (STDN). Formally established in 2002, the STDN is an important component of the National Sea Turtle Stranding and Salvage Network. The STDN works to reduce serious injuries and mortalities caused by entanglements and is active throughout the action area responding to reports of entanglements. Where possible, sea turtles are disentangled and may be brought back to rehabilitation facilities for treatment and recovery. This helps to reduce the rate of death from entanglement. The Southeast STDN provides similar services in the South Atlantic and Gulf of America. Sea turtles are also captured in fisheries operating in the Gulf of America and in offshore areas where pelagic fisheries such as the Atlantic Highly Migratory Species (HMS) fishery occurs.

5.6.1 Federally Managed Fisheries

In the Northwest Atlantic, NMFS Greater Atlantic Regional Office (GARFO) implements Federal fishery management plans fisheries from Maine to Cape Hatteras, North Carolina; however, the management areas for some of these fisheries range from Maine through Virginia, while others extend as far south as Key West, Florida. The NMFS Southeast Regional Office (SERO) implements Federal fishery management plans for Federal fisheries from Cape Hatteras, North Carolina to Texas, including Puerto Rico and the U.S. Virgin Islands. The NMFS Atlantic Highly Migratory Species (HMS) Division manages Federal HMS fisheries for tunas, sharks, swordfish, and billfish in U.S. Atlantic Ocean, Gulf of America, and Caribbean waters. The GARFO, SERO and HMS NMFS offices all conduct ESA section 7 consultations on all Federal fisheries authorized under their jurisdiction.

The Federal fishery consultations noted above have all considered adverse effects to green, Kemp's ridley, loggerhead, and leatherback sea turtles. In each of the fishery opinions, NMFS concluded that the ongoing action was likely to adversely affect but was not likely to jeopardize the continued existence of any sea turtle species. Each of these opinions included an ITS exempting a certain amount of lethal or non-lethal take resulting from interactions with the fisheries. Table 48 shows the incidental take of ESA-listed turtles and Atlantic sturgeon exempted as a result of the 2021 biological opinion and ITS on the American Lobster, Atlantic Bluefish, Atlantic Deep-Sea Red Crab, Mackerel/Squid/Butterfish, Monkfish, Northeast Multispecies, Northeast Skate Complex, Spiny Dogfish, Summer Flounder/Scup/Black Sea Bass, and Jonah Crab Fisheries. Table 49 shows the exempted take for sea turtles from all other current section 7 fisheries consultations on the U.S. Atlantic coast.

Table 48. Average Annual Exempted Take of Sea Turtles and Atlantic Sturgeon over a 5-Year Period as a Result of the 2021 Biological Opinion and ITS on the American Lobster, Atlantic Bluefish, Atlantic Deep-Sea Red Crab, Mackerel/Squid/Butterfish, Monkfish, Northeast Multispecies, Northeast Skate Complex, Spiny Dogfish, Summer Flounder/Scup/Black Sea Bass, and Jonah Crab fisheries (NMFS 2021b)

Species	Average Annual Total Take	Average Annual Lethal Take
<i>Sea Turtles</i>		
Green, North Atlantic DPS	Gillnet: 2 Trawl: 6.4	Gillnet: 1.6 Trawl: 3.2
Kemp's ridley	Gillnet: 47.8 Trawl: 10.6	Gillnet: 37.4 Trawl: 5.4
Loggerhead, NWA DPS	Gillnet: 207.2 Trawl: 190.8 Pot/trap: 1	Gillnet: 161.6 Trawl: 95.4 Pot/trap: 0.8
Leatherback	Gillnet: 10.4 Trawl: 8 Pot/trap: 10	Gillnet: 8.2 Trawl: 4 Pot/trap: 6.4
Any combination of turtle species	Vessel strike: 3	Vessel strike: 3
<i>Atlantic Sturgeon</i>		

Atlantic sturgeon, Gulf of Maine DPS	Gillnet: 55 Trawl: 68	Gillnet: 11 Trawl: 4
Atlantic sturgeon, New York Bight DPS	Gillnet: 448 Trawl: 556	Gillnet: 90 Trawl: 28
Atlantic sturgeon, Chesapeake Bay DPS	Gillnet: 68 Trawl: 83	Gillnet: 13 Trawl: 4
Atlantic sturgeon, Carolina DPS	Gillnet: 16 Trawl: 20	Gillnet: 3 Trawl: 1
Atlantic sturgeon, South Atlantic DPS	Gillnet: 35 Trawl: 44	Gillnet: 7 Trawl: 2

Table 49. Exempted Take for Sea Turtles from all other Current Section 7 Fisheries Consultations on the U.S. Atlantic Coast

Fishery Management Plan	Date	Loggerhead	Kemp's ridley	Green	Leatherback
American lobster	July 31, 2014	1 (lethal or non-lethal)	0	0	7 (lethal or non-lethal)
Atlantic sea scallop	July 12, 2012 (amended November 2018)	322 (92 lethal) over 2 years in dredges; 700 (330 lethal) over 5 years in trawls	3 (2 lethal) in dredges and trawls combined	2 (lethal) in dredges and trawls combined	2 (lethal) in dredges and trawls combined
Red Crab	February 6, 2002	1 (lethal or non-lethal)	0	0	1 (lethal or non-lethal)
Coastal migratory pelagics	June 18, 2015, amended 2017	27 over 3 years (7 lethal)	8 over 3 years (2 lethal)	31 over 3 years (9 lethal)	1 over 3 years (1 lethal)
South Atlantic snapper-grouper	December 1, 2016	629 (208 lethal) over 3 years	180 (59 lethal) over 3 years	111 (42 lethal) over 3 years	6 (5 lethal) over 3 years
Southeastern U.S. shrimp	April 26, 2021	72,670 (2,150 lethal) over 5 years	84,495 (8,505 lethal) over 5 years	21,214 (1,700 lethal) over 5 years	130 (5 lethal) over 5 years
HMS fisheries, excluding pelagic longline	January 10, 2020	91 (51 lethal) over 3 years	22 (11 lethal) over 3 years	46 (21 lethal) over 3 years	7 (3 lethal) over 3 years
HMS, pelagic longline	May 15, 2020	1080 (280 lethal) over 3 years	21 (8 lethal) combined Kemp's ridley, green (includes N. Atlantic and S. Atlantic DPS),	996 (275 lethal) over 3 years	HMS, pelagic longline

			hawksbill, or olive ridley over 3 years		
South-Atlantic dolphin- wahoo	August 27, 2003	12 (2 lethal)	3 (1 lethal) combination of Kemp's ridley, green, or hawksbill	12 (1 lethal)	South-Atlantic dolphin- wahoo

For Atlantic sturgeon, incidental take from fisheries bycatch is also exempted for the following fisheries:

- Atlantic sea scallop - 1 sublethal annually, 1 lethal every 20 years from any DPS;
- Coastal Migratory Pelagics - 12 sublethal every 3 years, 0 lethal across all DPSs;
- Southeastern U.S. Shrimp (every 5 years) – Gulf of Maine DPS 2 sublethal, 0 lethal; New York Bight DPS 7 sublethal, 2 lethal; Chesapeake DPS 19 sublethal, 4 lethal; Carolina DPS 66 sublethal, 15 lethal; S. Atlantic DPS 103 sublethal, 24 lethal;
- HMS fisheries, excluding pelagic longline (every 3 years) – Gulf of Maine DPS 34 sublethal, 8 lethal; New York Bight DPS 170 sublethal, 36 lethal; Chesapeake DPS 40 sublethal, 9 lethal; Carolina DPS 10 sublethal, 5 lethal; S. Atlantic DPS 75 sublethal, 19 lethal;

Table 50 shows the estimated average annual sea turtle interactions in select commercial fishing gears in the Mid-Atlantic and Georges Bank regions. The 2017 Atlantic Sturgeon Benchmark Stock Assessment (ASMFC 2017) estimated that, on average, 1,139 Atlantic sturgeon (295 lethal; 25%) were caught in gillnet fisheries and 1,062 (41 lethal; 4%) were caught in otter trawl fisheries each year from 2000 to 2015. Atlantic sturgeon bycatch estimates for Northeast gillnet and trawl gear from 2011 to 2015 (approximately 761 fish per year for gillnets, 777 per year for trawls) are substantially lower than those from 2006 to 2010 (approximately 1,074 fish per year for gillnets, 1,016 per year for trawls) (ASMFC 2017).

Table 50. Estimated Average Annual Sea Turtle Interactions in Select Commercial Fishing Gears in the Mid-Atlantic and Georges Bank Regions (numbers in parentheses are adult equivalents)

Gear	Years	Area	Estimated Interactions (adult equivalents)	Mortalities (adult equivalents)	Source
Sea Scallop Dredge	2009-2014	Mid-Atlantic	Loggerhead: 22 (2)	9-19* (1-2)	Murray (2015)
Sink Gillnet	2012-2016	Mid-Atlantic	Loggerhead: 141(3.8) Kemp's ridley: 29 Leatherbacks: 5.4 Unid. hardshell: 22.4	Loggerhead: 111.4 Kemp's ridley: 23 Leatherbacks: 4.2 Unid. hardshell: 17.6	Murray (2018)

Bottom Trawl	2014-2018	Mid-Atlantic and Georges Bank	Loggerhead: 116.6 (36.4) Kemp's ridley: 9.2 Green: 3.2 Leatherbacks: 5.2	Loggerhead: 54.4 (17.4) Kemp's ridley: 4.6 Green: 1.6 Leatherbacks: 2.6	Murray (2020)

*Of these interactions, 9-19 would result in mortality depending on whether loggerheads that interacted with chain mats without being captured (the unobservable but quantifiable interactions) survived.

The Gulf of America reef fish fishery uses two basic types of gear: spear or powerhead, and hook-and-line gear. Hook-and-line gear used in the fishery includes both commercial bottom longline and commercial and recreational vertical line (e.g., handline, bandit gear, rod-and-reel). Prior to 2008, the reef fish fishery was believed to have relatively moderate levels of sea turtle bycatch attributed to the hook-and-line component of the fishery (i.e., approximately 107 captures and 41 mortalities annually, all species combined, for the entire fishery) (NMFS 2005a). In 2008, NMFS SEFSC observer programs and subsequent analyses indicated that the overall amount and extent of incidental take for sea turtles specified in the ITS of the 2005 opinion on the reef fish fishery had been severely exceeded by the bottom longline component of the fishery: approximately 974 captures and at least 325 mortalities estimated for the period from July 2006 through 2007. In response, NMFS published an Emergency Rule prohibiting the use of bottom longline gear in the reef fish fishery shoreward of a line approximating the 50-fathom depth contour in the eastern Gulf of America, essentially closing the bottom longline sector of the reef fish fishery in the eastern Gulf of America for six months pending the implementation of a long-term management strategy. The Gulf Fishery Management Council developed a long-term management strategy via a new amendment: Amendment 31 to the Reef Fish Fishery Management Plan (GMFMC 2010). The amendment included: (1) a prohibition on the use of bottom longline gear in the Gulf of America reef fish fishery, shoreward of a line approximating the 35-fathom contour east of Cape San Blas, Florida, from June through August and ; (2) a reduction in the number of bottom longline vessels operating in the fishery via an endorsement program and a restriction on the total number of hooks that may be possessed onboard each Gulf of America reef fish bottom longline vessel to 1,000, only 750 of which may be rigged for fishing.

The U.S. Federal shrimp trawl fishery has reported the capture of 13 smalltooth sawfish from 2009 to 2018, although this number likely represents a small portion of actual captures given the low observer coverage of this fishery (Brame et al. 2019). Extrapolated total take estimates for the shrimp trawl fishery for the period 2008–2010 indicate that a total of 17 to 163 smalltooth sawfish were captured per year (Carlson and Scott-Denton 2011). The shrimp trawl fishery is of particular concern, as interactions with this fishery generally result in the mortality of large and likely mature sawfish, thus reducing reproductive potential within the population (Brame et al. 2019). While sawfish are also incidentally caught in the Federal shark bottom longline fishery, based on the live release of large sawfish from longline gear, it is expected that sawfish are more resilient to capture on this gear in comparison to trawls and gill nets (Prohaska et al. 2018; Poulakis and Grubbs 2019).

5.6.2 State Managed Fisheries

Several fisheries for species not managed by a Federal fishery management plan occur in state waters of the action area. Gear types used in these fisheries include hook-and-line, gillnet, trawl, pound net and weir, trap/pot, seines, and channel nets. ESA-listed sea turtles and fishes interact with these fishing gears in state waters. In most cases, there is limited observer coverage of these fisheries, and the extent of interactions with ESA-listed species is difficult to estimate.

In 2013, after amending their commercial fishing regulations to minimize incidental capture, the Georgia Department of Natural Resources received an ESA section 10 permit for incidental take of Atlantic sturgeon in the commercial shad fishery in state waters. The incidental take permit (ITP) allows the capture and live release of up to 180 Atlantic sturgeon annually, with a maximum of five incidental mortalities per year. A mortality rate of approximately 2.3% is anticipated based on recent research. The North Carolina Division of Marine Fisheries (NCDMF) developed a Conservation Plan to address Atlantic sturgeon take in the state's inshore gillnet fishery, and submitted an application for an ESA ITP to NMFS in April of 2012. In July 2014, NCDMF received an ESA section 10 permit for incidental take of Atlantic sturgeon that allows for take of up to 2,927 juvenile and small subadult Atlantic sturgeon annually, primarily in the form of capture and harassment, but in some cases lethal take.

NCDMF reported that no Atlantic sturgeon were observed in 958 observed tows conducted from 2001 to 2008 by commercial shrimp trawlers working in North Carolina waters (NCDMF 2014). Collins et al. (1996) reported that of 1,534 juvenile Atlantic sturgeon tagged in the Altamaha River, Georgia, 38 out of 97 (39%) were recaptured in shrimp trawls with the remainder captured in gillnet fisheries. Seven adult Atlantic sturgeon were captured (one killed) by a single shrimp trawler off Winyah Bay, South Carolina in October 2008 (Damon-Randall et al. 2010).

Information on the number of Atlantic sturgeon captures and mortalities in non-federal fisheries, which primarily occur in state waters, is extremely limited. An Atlantic sturgeon "reward program" provided commercial fishermen monetary rewards for reporting captures of Atlantic sturgeon in Maryland's Chesapeake Bay (Mangold et al. 2007). The data from this program show that Atlantic sturgeon have been caught in a wide variety of gear types, including hook and line, pound nets, gillnets, crab pots, eel pots, hoop nets, trawls, and fyke nets. Pound nets (58.9%) and gillnets (40.7%) accounted for the vast majority of captures (NMFS 2021b). Of the more than 2,000 Atlantic sturgeon reported in the reward program over 16 years (1996-2012), an estimated ten fish died due to capture in commercial gear (NMFS 2021b).

Gulf sturgeon are also captured in state managed fisheries. The Gulf sturgeon recovery plan (USFWS and GSMFC 1995) documents that Gulf sturgeon are occasionally incidentally captured in state shrimp fisheries in bays and sounds along the northern Gulf of America. There are two recorded interactions of a Gulf sturgeon with the shrimp trawl fishery: one in Federal waters (January 1, 2011) and one in state waters of the Gulf of America (December 15, 2009). In the Pearl River, Mississippi/Louisiana, a trammel/gillnet fishery is conducted for gar. Because of the gear (minimum of 3 in. mesh square, up to 3,000 ft in length) and the year-around nature of

the fishery, it is probable that Gulf sturgeon are intercepted in this fishery. While state regulations prohibit taking or possession of whole or any body parts, including roe, there is no reporting to determine capture or release rates.

Smalltooth sawfish are captured incidentally in recreational fisheries, although the level of mortality is likely low when sawfish are handled and released properly. However, researchers continue to receive reports of sawfish either being illegally retained or being released after the removal of their rostra (Brame et al. 2019).

5.7 Fishery Interactions and Entanglement

Fisheries interactions can result in significant demographic effects on populations of marine mammals, as entanglement in fishing gear represents a major source of injury and mortality for some species (Read et al. 2006). Bycatch mortality is estimated globally to exceed hundreds of thousands of marine mammals each year (Read et al. 2006). Many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to fully assess the magnitude of this threat. When not immediately fatal, entanglement or ingestion of fishing gear can impede the ability of marine mammals to feed and can cause injuries that eventually lead to infection and death (e.g., Wells et al. 2008; Cassoff et al. 2011; Moore and Van der Hoop 2012). Other sublethal effects of entanglement include increased vulnerability to additional threats, such as predation and ship strikes, by restricting agility and swimming speed. There are also costs likely to be associated with nonlethal entanglements in terms of energy and stress (Moore and Van der Hoop 2012).

We have reviewed the most recent data available on reported entanglements for the ESA-listed whale stocks that occur in the action area (Hayes et al. 2022; Henry et al. 2022; Hayes et al. 2023). As reported in the most recent U.S. Atlantic and Gulf of Mexico Stock Assessment Report (SAR), the average annual rate of serious injury or mortality resulting from fishery interactions is as follows for the ESA-listed marine mammals in the action area (note: years based on shown in parentheses): 4.0/year for North Atlantic right whales (2018 to 2022); 1.45/year for fin whales (2017 to 2021); 0.4/year for sei whales (2017 to 2021); and 0.2/year for sperm whales (2014 to 2018). The average annual rate of serious injury or mortality resulting from fishery interactions is zero for blue and Rice's whales, as there have been no such interactions reported in the recent past. For all species, these estimated rates represent the minimum number of whales entanglement since these data represent only known mortalities and serious injuries. Many more undocumented mortalities and serious injuries from entanglement have likely occurred and gone undetected (or unreported) due to the offshore habitats where large whales typically occur. Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd et al. 2014). The effects of entanglement on North Atlantic right whales, including a discussion of the current UME, are discussed in more detail in the North Atlantic right whale status of the species Section 4.2.1.

Implementation of the Atlantic Large Whale Take Reduction Plan (ALWTRP) will likely reduce the number of large whale injuries and deaths due to incidental entanglement in fishing gear in the future. The ALWTRP is an evolving plan that changes as NMFS learns more about why whales become entangled and how fishing practices might be modified to reduce the risk of entanglement. It has several components including restrictions on where and how gear can be set; research into whale populations and whale behavior, as well as fishing gear interactions and modifications; outreach to inform and collaborate with fishermen and other stakeholders; and a large whale disentangling program that seeks to safely remove entangling gear from large whales whenever possible.

5.8 Historical Whaling

Whale populations within the action area have historically been impacted by aboriginal subsistence hunting, small-scale commercial whaling and, more recently, large-scale commercial whaling using factory ships. From 1864 through 1985, at least 2,400,000 baleen whales (excluding minke whales) and sperm whales were killed globally (Gambell 1999). Many of the whaling numbers reported in the 20th century likely represent minimum estimates, as illegal or underreported catches are not included.

Prior to current prohibitions on whaling, most large whale species were significantly depleted to the extent it was necessary to list them as endangered under the Endangered Species Preservation Act of 1966. Right whales were depleted throughout the western North Atlantic by the middle of the 18th century, but small shore whaling enterprises persisted in some areas and pelagic whalers continued to kill right whales opportunistically (Reeves 2020). An increase in alongshore whaling occurred at Long Island (New York) beginning in the 1850s and in North and South Carolina, Georgia and northern Florida in the 1870s through 1880s. By the start of the 20th century only a few crews of shore whalers remained active in Long Island and North Carolina (Reeves 2020). The Gulf of America was among the regions visited by American commercial whalers beginning in the mid to late 1700s (Reeves et al. 2011). For more than a century, the whale fishery in the Gulf of America was focused on sperm whales, with “blackfish” (probably pilot whales, killer whales or porpoises) as secondary targets. The sperm whales hunted in the Gulf of America tended to be small and were usually taken from schools, suggesting that they were mostly juveniles and females (Reeves et al. 2011).

In 1982, the International Whaling Commission issued a moratorium on commercial whaling, which went into effect in 1986. There is currently no legal commercial whaling by International Whaling Commission Member Nations party to the moratorium; however, whales are still killed commercially by countries that filed objections to the moratorium. Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted either under objection or reservation to the IWC moratorium (i.e., Iceland and Norway). Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation. Since the end of large-scale commercial whaling, the primary threat to these species has been eliminated, although many whale species have not yet fully recovered from those historic declines.

5.9 Aquaculture

Marine aquaculture systems are diverse, ranging from highly controlled land-based systems to open water cages that release wastes directly to the environment. Species produced in the marine environment are also diverse, and include seaweeds, bivalve mollusks, echinoderms, crustaceans, and finfish (Langan 2004). Globally, aquaculture supplies more than 50% of all seafood produced for human consumption, and that percentage will likely continue to rise (NOAA Marine Aquaculture website <https://www.fisheries.noaa.gov/topic/aquaculture>). Marine aquaculture is expected to expand in the U. S. EEZ due to increased demand for domestically grown seafood, coupled with improved technological capacity to farm in the open ocean. The National Offshore Aquaculture Act of 2005 (S. 1195) promotes offshore aquaculture development within the EEZ and established a permitting process that encourages private investment in aquaculture operations, demonstrations, and research. Although the marine aquaculture industry has been expanding in the U.S., development is highly variable among states (e.g., Virginia and Maine have productive and valuable industries, while Georgia and New York, have relatively minimal development) (Lester et al. 2024).

Potential impacts can occur at all stages of aquaculture development, operation, and decommissioning and can include attraction to farms or displacement from important habitats, resulting in changes to distribution, behaviors, or social structures (Clement 2013; Price et al. 2017). Aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, increased vessel traffic and noise, impacts to habitat and benthic organisms, and water quality (Lloyd 2003; Clement 2013; Price and Morris 2013; Price et al. 2017). Current data suggest that interactions and entanglements of ESA-listed marine mammals and sea turtles with aquaculture gear are rare (Price et al. 2017). This may be because worldwide the number and density of aquaculture farms are low, and thus there is a low probability of interactions, or because they pose little risk of ESA-listed marine mammals and sea turtles. There are very few reports of marine mammal interactions with aquaculture gear, although it is not always possible to determine if the gear animals become entangled in is from aquaculture or commercial fisheries (Price et al. 2017). Also, some aquaculture gear has the potential for behavioral effects on marine mammals. For example, aquaculture gear may act as a "fish aggregating device" which may attract marine mammals seeking prey for food, or depredation may occur (Callier et al. 2018). Aquaculture gear may also block migration routes (MPI 2013) or at least cause animals to have to circumnavigate the aquaculture gear.

5.10 Vessel Strike

Vessel strike represents a recognized, ongoing threat to several ESA-listed species in the action area including large whales, sea turtles, and sturgeon. We discuss vessel strike here as part of the environmental baseline, and refer the reader to our vessel strike analysis sections for marine mammal, sea turtle, and fish (Sections 6.1.2, 6.2.2, and 6.3.2, respectively) for more details.

5.10.1 Marine Mammals

We reviewed the best available data on reported vessel strikes of ESA-listed whale species within the action area (Hayes et al. 2020; Hayes et al. 2022; Henry et al. 2022; Hayes et al. 2023; Hayes et al. 2024). As reported in the most recent U.S. Atlantic and Gulf of Mexico SAR, the average annual rate of serious injury or mortality resulting from vessel strike is as follows for the ESA-listed marine mammals in the action area (note: years based on shown in parentheses): 1.5/year for North Atlantic right whales (2018 to 2022); 0.6/year for fin whales (2017 to 2021); 0.0/year for sei, sperm, Rice's, and blue whales (2017 to 2021).

For all species, these estimated rates represent the minimum number of large whale vessel strikes since these data represent only known mortalities and serious injuries. Many more undocumented mortalities and serious injuries from entanglement have likely occurred and gone undetected (or unreported) due to the offshore habitats where large whales typically occur, and that fact that most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff et al. 2011). Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of mortalities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). For example, Blondin et al. (2025) estimated an annual mortality rate of right whales due to vessel strike in U.S. waters of 17.5, which is significantly greater than the average annual number of documented right whale mortalities and serious injuries from vessel strike in U.S. waters of 2.4 whales over the same time period.

Therefore, although no vessel strikes have been documented for some ESA-listed marine mammals considered in this opinion in recent years, there are historical vessel strike reports within the action areas for all of these species, and undocumented strikes may have occurred more recently. Rice's whales may be at higher risk for strike because they spend much of their time at night at or near the water surface. Constantine et al. (2015) studied another critically small and endangered population of Bryde's whales in Hauraki Gulf, New Zealand and determined that vessel strike was a substantial threat to that population especially at night when the whales spend an increased amount of time close to the water surface. In 2009, a Rice's whale was found floating in the Port of Tampa, Tampa Bay, Florida. The whale had evidence of pre-mortem and post-mortem blunt trauma, and was determined to have been struck by a vessel, draped across the bow, and carried into port (Hayes et al. 2023). In addition, Rosel et al. (2021) reported a 2019 sighting of a free-swimming Rice's whale with a spinal deformation consistent with a vessel strike at some point in the past.

As discussed in status of the species (Section 4.2.1), vessel strike remains one of the primary threats to the survival and recovery of North Atlantic right whales. Schleimer et al. (2019) studied changes in abundance and survival rates of fin whales in the northern Gulf of St. Lawrence in the context of anthropogenic pressures and changing environmental conditions. They found that vessel strikes and changes in prey availability were potential drivers of the observed recent decline in this fin whale population's abundance.

To comply with the Ship Strike Reduction Rule (50 CFR 224.105), vessels²¹ greater than or equal to 65 ft (19.8 m) in overall length and subject to the jurisdiction of the U.S., and all vessels greater than or equal to 65 ft in overall length entering or departing a port or place subject to the jurisdiction of the U.S., must slow to speeds of 10 knots or less in North Atlantic right whale seasonal management areas (SMA). Mandatory speed restrictions of 10 knots or less are required in all of the SMAs along the U.S. East Coast during times when right whales are likely to be present; a number of these SMAs overlap with the portion of the action area that may be used by project vessels. The purpose of this regulation is to reduce the likelihood of deaths and serious injuries to these endangered whales that result from collisions with ships. The Mid-Atlantic SMA in the action area extends from the mouth of the Chesapeake Bay out to 37 km from shore, from November 1 to April 30. While the Mid-Atlantic SMA likely reduces vessel strike risk, recent sightings from surveys within the VACAPES OPAREA suggest that North Atlantic right whales are utilizing areas that are further offshore within this region (Ozog and D. 2025). Since 2018, over 90% of all North Atlantic right whale survey sightings (n=48) occurred outside the Mid-Atlantic SMA (A. Westell personal communication, presentation at the U.S. Navy Marine Species Monitoring Program Review meeting, Norfolk, VA, April 2, 2025). In 2024, a mature female North Atlantic right whale carcass with signs of vessel strike was sighted within the VACAPES OPAREA (Ozog and D. 2025).

SMAs are supplemented by Dynamic Management Areas (DMAs) that are implemented for 15-day periods in areas in which right whales are sighted outside of SMA boundaries (73 FR 60173; October 10, 2008). DMAs can be designated anywhere along the U.S. eastern seaboard, including within the action area in the Atlantic Ocean, when NOAA aerial surveys or other reliable sources report aggregations of three or more right whales in a density that indicates the whales are likely to persist in the area. DMAs are implemented for two weeks in an area that is commensurate to the number of right whales present. Mariners are notified of DMAs via email, the internet, Broadcast Notice to Mariners (BNM), NOAA Weather Radio, and the Mandatory Ship Reporting system (MSR). NOAA requests that mariners voluntarily navigate around these zones or transit through them at 10 knots or less. In 2021, NMFS supplemented the DMA program with a new Slow Zone program, which identifies areas for recommended 10-knot speed reductions based on acoustic detection of right whales. Together, these zones are established around areas where right whales have been recently seen or heard. The program provides maps and coordinates to vessel operators indicating areas where they have been detected. Compliance with these zones is voluntary.

Lagueux et al. (2011) reported that vessel compliance was significantly higher under mandatory versus voluntary right whale recommended speed restrictions, with compliance rates of 75% and 16%, respectively. Average vessel speeds were slower under mandatory speed restrictions (10.5

²¹ Exceptions to this rule include U.S. vessels owned or operated by, or under contract to, the Federal Government (including military vessels) and law enforcement vessels of a State, or political subdivision thereof, when engaged in law enforcement or search and rescue duties.

knots, 19.6 km h⁻¹) compared to voluntary recommended speed restrictions (14.5 knots, 26.9 km h⁻¹) (Lagueux et al. 2011).

Restrictions limit how close vessels can approach right whales to reduce vessel-related impacts, including disturbance. NMFS rulemaking (62 FR 6729, February 13, 1997) restricts vessel approach to right whales to a distance of 500 yds. This rule is expected to reduce the potential for vessel strike and other adverse vessel-related effects to North Atlantic right whales. The MSR requires ships entering the northeast and southeast MSR boundaries to report the vessel identity, date, time, course, speed, destination, and other relevant information. In return, the vessel receives an automated reply with the most recent right whale sightings or management areas and information on precautionary measures to take while in the vicinity of right whales.

5.10.2 Sea Turtles

Propeller and collision injuries and mortalities from private and commercial vessels are also a significant threat to ESA-listed sea turtles. Sea turtles swimming or feeding at or just beneath the surface of the water are particularly vulnerable to vessel strikes, which can result in serious injury and death (Hazel et al. 2007). Sea turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases (Hazel et al. 2007). Results from a study by Hazel et al. (2007) suggest that green sea turtles cannot consistently avoid being struck by vessels moving at relatively moderate speeds (i.e., greater than 4 km per hour).

Many recovered sea turtles display injuries that appear to result from interactions with vessels and their associated propulsion systems (Work et al. 2010). This is particularly true in nearshore areas with high vessel traffic along the U.S. Atlantic and Gulf of America coasts. From 1997 to 2005, nearly 15% of all stranded loggerheads in the U.S. Atlantic and Gulf of America were documented as having sustained some type of propeller or collision injury. An analysis of stranded sea turtles in the northern Gulf of Mexico (Alabama, Mississippi, and Louisiana) from 2015-2019 found that approximately 13% had vessel strike injuries (Howell et al. 2021). Similarly, Kincaid et al. (in press) found that 16% of 2,251 stranded sea turtles in Sarasota County and Longboat Key, Florida from 1987-2021 had evidence of at least one vessel strike injury.

The incidence of propeller wounds of stranded sea turtles from the U.S. Atlantic and Gulf of America doubled from about 10% in the late 1980s to about 20% in 2004. Singel et al. (2007) reported a tripling of boat strike injuries in Florida from the 1980's to 2005. Over this time period, in Florida alone over 4,000 (approximately 500 live and 3,500 dead) sea turtle strandings were documented with propeller wounds, which represents 30% of all sea turtle strandings for the state (Singel et al. 2007). These studies suggest that the threat of vessel strikes to sea turtles may be increasing over time as vessel traffic continues to increase in the southeastern U.S.

The Sea Turtle Stranding and Salvage Network reports a large number of vessel interactions (propeller injury) with sea turtles off coastal states such as New Jersey and Florida, where there

are high levels of vessel traffic. The Virginia Aquarium & Marine Science Center Strandings Program reported an average of 62.3 sea turtle strandings per year in Virginia waters due to boat strikes from 2009-2014 (Barco 2015). The large majority of these (about 87%) were dead strandings. By sea turtle species, 73.3% of Virginia vessel strike strandings from 2009 to 2014 were loggerhead, 20.3% Kemp's ridley, 3.5% green, and 2.9% leatherback (Barco 2015).

5.10.3 Sturgeon

Large sturgeon are susceptible to vessel collisions. The factors relevant to determining the risk to sturgeon from vessel strikes are likely related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of sturgeon in the area (e.g., foraging, migrating, etc.). The regular jumping and breaching behavior of sturgeon may also put them at risk of strikes by large vessels at the water surface (Edwards et al. 2007). Multiple studies have shown that Atlantic sturgeon are unlikely to move away from vessels or avoid areas with vessel activity (Reine et al. 2014; DiJohnson 2019; Balazik et al. 2020). In 2012, when Atlantic sturgeon were listed, vessel strikes were considered a primary threat to the New York Bight and Chesapeake Bay DPSs. In particular, sturgeon from the Hudson River spawning population were likely to be impacted by vessel strikes from large commercial vessels in the Delaware and James rivers due to the sturgeon's use of those non-natal estuaries. The Atlantic Sturgeon Status Review Team determined Atlantic sturgeon in the Delaware River are at a moderately high risk of extinction because of vessel strikes, and sturgeon in the James River are at a moderate risk from vessel strikes (ASSRT 2007). Balazik et al. (2012b) estimated up to 80 sturgeon were killed by vessel strike between 2007 and 2010 in these two river systems combined. Brown and Murphy (2010) examined 28 dead Atlantic sturgeon from the Delaware River from 2005 through 2008 and found that 50% of the mortalities resulted from apparent vessel strikes, and 71% of these (10 out of 14) had injuries consistent with being struck by a large vessel. Eight of the fourteen vessel-struck sturgeon were adult-sized fish which, given the time of year the fish were observed, were likely migrating through the river to or from the spawning grounds. Based on evidence of Atlantic sturgeon vessel strikes since the listing, it is now apparent that vessel strikes are also occurring in the Hudson River (NMFS 2022a). For example, the New York Department of Environmental Conservation reported that at least 17 dead Atlantic sturgeon with vessel strike injuries were found in the river in 2019, of which at least 10 were adults (NMFS 2022a).

From 2007 to 2010, researchers documented 31 carcasses of adult Atlantic sturgeon in the tidal freshwater portion of the James River, Virginia. Twenty-six of the carcasses had gashes from vessel propellers, and the remaining five carcasses were too decomposed to allow determination of the cause of death (Balazik et al. 2012a). The researchers could not fully attribute all of these mortalities to specific types of vessels, but it is likely they resulted from larger vessels in narrow shipping lanes, similar to what has been observed for the Delaware River. In 2016, Balazik also reported that ship strikes in Virginia are not just limited to confined river systems (Figure 53) (Balazik 2016). These data indicate 91 sturgeon were hit by vessels between 2007 and 2016. Data from 2015 and 2016 indicate ship strikes of Atlantic sturgeon occur with some frequency

within the lower Chesapeake Bay and even along the Atlantic coast. It should be noted the location of the reported fish does not necessarily reflect where the fish was struck by a vessel, only where it was observed washed ashore or floating in the water. It is also hard to determine with a high degree of certainty whether or not the vessel strike was the cause of death, meaning it is possible that a fish that was dead already, and subsequently hit by a vessel because it was floating in the water column.

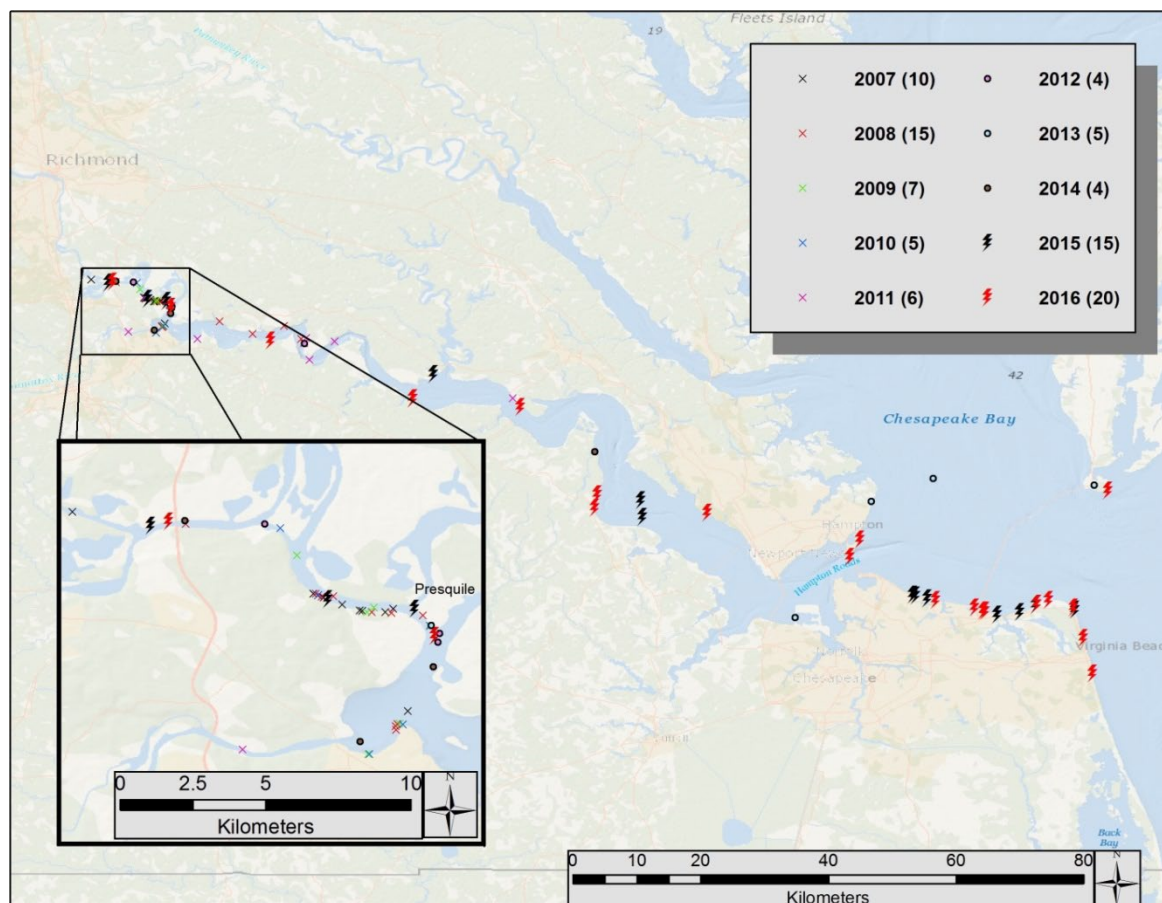


Figure 53. Documented Ship Strikes of Atlantic Sturgeon between 2007 and 2016 (Balazik 2016)

Reported vessel strikes represent only minimum counts of the number of Atlantic sturgeon that are actually struck and killed by vessels because the majority of carcasses are either not found or not reported. Balazik et al. (2012b) estimated that 31% (5 out of 16) deceased Atlantic sturgeon released in the James River, VA were eventually reported. However, the carcass reporting rate from this study likely underestimated the number of unobserved mortalities since the study occurred over a short time (approximately 4 weeks) in a single year and the researchers were actively searching for the carcasses, which is different from opportunistic sightings and receiving reports from the public. Fox et al. (2020) estimated Atlantic sturgeon carcass reporting rates for the Delaware River and Estuary based on multiple sources of reporting. Estimated reporting rates varied from 2.0% (spring 2018) to 12.5% (summer and fall 2018) with an average

reporting rate of 4.76% when they combined the data for all seasons over the two years (2018 and 2019) of the study.

To date, there have been five documented Gulf sturgeon mortalities that exhibited clear signs of collision with large vessels (USFWS and NMFS 2022). This may be a result of low rates of Gulf sturgeon ship strikes, or low rates of reporting where ship strikes are occurring. The threat of ship strikes may increase in areas of the northern Gulf of America where barge and tug boat traffic associated with coastal protection, restoration, and infrastructure activities is expected to increase (USFWS and NMFS 2022). Gulf sturgeon are also known to jump out of the water, and this behavior has resulted in several documented accidents with boaters in the Suwannee River and Santa Fe River in Florida in recent years (see <https://myfwc.com/conservation/you-protect/wildlife/sturgeon/>).

5.11 Invasive Species

The introduction of non-native species is considered one of the primary threats to endangered species globally (Anttila et al. 1998; Wilcove and Chen 1998; Pimentel et al. 2004). Clavero and Garcia-Bertro (2005) found that invasive species were a contributing cause to over half of the extinct species in the International Union for Conservation of Nature database and invasive species were the only cited cause in 20% of those cases. Invasive species consistently rank as one of the top threats to the world's oceans (Raaymakers and Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Wambiji et al. 2007; Pughiuc 2010).

When non-native plants and animals are introduced into habitats where they do not naturally occur, they can have significant impacts on ecosystems and native fauna and flora (including ESA-listed species). Non-native species can be introduced through infested stock for aquaculture and fishery enhancement, ballast water discharge, and from the pet and recreational fishing industries. In general, species located higher within a food web (including most ESA-listed species under NMFS' jurisdiction) are more likely to become extinct as a result of a non-native species invasion. Conversely, non-native species that are more centrally or bottom-oriented within a food web are more likely to become established as invasive (Harvey and May 1997; Byrnes et al. 2007). Propagule pressure is generally the reason for this trend, as individuals lower in the food web tend to have higher fecundity and lower survival rates (r-selection). This unbalancing of food webs makes subsequent introductions more likely as resource utilization shifts, increasing resource availability, and exploitation success by non-native species (Barko and Smart 1981; Byrnes et al. 2007). Such shifts in the base of food webs fundamentally alters predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002).

For example, non-native invertebrate species can have major impacts on the ecosystems they invade. Benthic invertebrates, such as mussels, polychaetes, and hydroids can become dominant filter feeders, greatly reducing the amount of organic energy that is available to native taxa in the water column (NMFS 2012). This transfer of energy from the water column into the benthos fundamentally alters the ecology of the host habitat, resulting in less prey available for other filter feeders. Adverse effects of this include reduced body condition, growth, survival, and/or reproduction of native pelagic organisms at the same or similar trophic level as the invader if the

native competitor cannot adapt to another food source. These changes would be manifested to a greater or lesser degree up the food chain to higher trophic level organisms in the habitat, including ESA-listed sturgeon and sea turtles (NMFS 2012). Invasive species may also prey upon ESA-listed species. For example, the crown-of-thorns sea star *Acanthaster planci* can significantly disrupt localized coral reef ecosystems by feeding on live coral (e.g., Colgan 1987; Timmers et al. 2012), including the ESA-listed coral species considered in this opinion.

Red tide dinoflagellates have been introduced via ballast water discharges and have the potential to undergo extreme seasonal population fluctuations, potentially resulting in significant adverse effects to ESA-listed species. During bloom conditions, high levels of neurotoxins are released into local and regional surface water and air that can cause illness and death in fishes, sea turtles, marine mammals, and invertebrates (as well as their larvae) (Hallegraeff and Bolch 1992; McMinn et al. 1997; Hallegraeff 1998; Hamer et al. 2000; Hamer et al. 2001; Lilly et al. 2002). The brown alga, *Aureococcus anophagefferens*, causes brown tide when it blooms, causing diebacks of eelgrass habitat due to blooms decreasing light availability and failure of scallops and mussels to recruit (Doblin et al. 2004).

Invasive species can adversely affect listed fish species through several mechanisms, including: predation, competition, trophic structure alteration, introgression, and transfer of pathogens (Sanderson et al. 2009). Both positive and negative impacts to fish species have been reported in the literature from the introduction of nonindigenous species (Schlaepfer et al. 2011). For example, channel catfish, small and largemouth bass, and walleye prey on juvenile salmon (Sanderson et al. 2009). Juvenile shad prey heavily on zooplankton, which are also the primary prey for juvenile salmonids (Haskell et al. 2006). Alternatively, some introduced species may serve as a food source for native species in the introduced environment. Vinson and Baker (2008) found that the nonindigenous mudsnail (*Potamopyrgus antipodarum*) was an abundant prey item for native salmonids. However, when native salmonids feed exclusively on mudsnails, this study found they lose 0.5% of their body weight per day. This study suggests that, in some cases, even if nonindigenous invertebrate species can provide a new food source, the resulting effect can still be detrimental to native fish species if the nonindigenous prey is not as nutritionally valuable as the native prey items that it is replacing.

Ray (2005) documented 74 nonindigenous estuarine and marine species in the Gulf of America, including 25 fish species. Florida had the greatest number of reported nonindigenous species, probably reflecting the length of coastline, the intensity of human influence (e.g., shipping and industrialization), and the extent of monitoring efforts in this state (Ray 2005). Species most commonly identified as invasive or listed as of concern in the Gulf of America include Australian spotted jellyfish (*Phylloriza punctate*), green-lipped mussel (*Perna viridis*), brown mussel (*Perna perna*), shipworms, green porcelain crab (*Petrolisthes armatus*), and lionfish (*Pterois volitans*) (Ray 2005). Lionfish populations continue to expand at astonishing speeds and are harming native coral reef ecosystems in the Atlantic, Gulf of America, and Caribbean (NOAA 2025). Adult lionfish feed primarily on native herbivorous fish species and have very few natural predators outside of their home range. A single lionfish residing on a coral reef can reduce recruitment of native reef fish by nearly 80% (NOAA 2025). The removal of algae eating

herbivores from reef systems can result in ecosystem imbalance with adverse effects to coral and other native species dependent on healthy reefs.

5.12 Diseases and Parasites

Fibropapillomatosis is a neoplastic disease that can negatively impact ESA-listed sea turtle populations. Fibropapillomatosis has long been present in sea turtle populations with the earliest recorded mention from the late 1800s in the Florida Keys (Hargrove et al. 2016). Prevalence rates as high as 45 to 50% have been reported within some local green sea turtle populations within the action area (Jones et al. 2015; Hargrove et al. 2016). An increasing number of Kemp's ridley turtles have been reported with fibropapillomatosis in recent years, although prevalence of this disease is still relatively uncommon among this species (Page-Karjian et al. 2021).

Fibropapillomatosis is characterized by both internal and external tumorous growths, which can range in size from very small to extremely large. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness (Foley et al. 2005). Renan de Deus Santos et al. (2017) assessed stress responses (corticosterone, glucose, lactate, and hematocrit) to capture and handling in green sea turtles with different fibropapillomatosis severity levels. Their findings suggest that moderate fibropapillomatosis severity may affect a sea turtle's ability to adequately feed themselves (as evidenced by poor body condition), and advanced-stage fibropapillomatosis severity may result in an impaired corticosterone response. Despite some conflicting conclusions, the overwhelming consensus among sea turtle researchers is that, at present, fibropapillomatosis does not significantly impact the overall survival of sea turtle populations (Hargrove et al. 2016). However, it remains a health concern due to its uncertain pathogenesis and potential relationship with habitat degradation (Page-Karjian et al. 2021). Therefore, fibropapillomatosis cannot be discounted as a potential threat to sea turtle populations (particularly green sea turtles) as the distribution, prevalence rate, severity, and environmental co-factors associated with the disease have the capacity to change over time (Jones et al. 2015).

Fish diseases and parasitic organisms occur naturally in the water. Many fish species are highly susceptible to parasites and disease, particularly during early life stages. Native fish have co-evolved with such organisms and individuals can often carry diseases and parasites at less than lethal levels. While disease organisms commonly occur among wild fish populations, under favorable environmental conditions these organisms are not expected to cause population-threatening epizootics. However, outbreaks may occur when stress from disease and parasites is compounded by other stressors such as diminished water quality, flows, and crowding (Spence and Hughes 1996; Guillen 2003). At higher than normal water temperatures fish species may become stressed and lose their resistance to diseases (Spence and Hughes 1996). Consequently, diseased fish become more susceptible to predation and are less able to perform essential functions, such as feeding, swimming, and defending territories (McCullough 1999). The introduction of non-indigenous fish pathogens to wild fish populations through aquaculture operations also represents a threat to some fish populations. The aquarium industry is another possible source for transfer of non-indigenous pathogens or non-indigenous species from one geographic area to another, primarily through release of aquaria fish into public waters.

Cetaceans have evolved with a group of parasites belonging to the genus *Crassicauda* (order Spirurida) (Lambertsen 1992). Infections with these nematodes are endemic in both the toothed and baleen whales. Such infections are a major cause of disease of the urinary, respiratory and digestive systems. Of several known crassicaudid infections, those caused by *Crassicauda boopis* are especially pathogenic. This giant worm infects blue whales, humpback whales, and fin whales (Lambertsen 1992). Jauniaux et al. (2000) reported evidence of morbillivirus infection in the two fin whales stranded on the Belgian and French coastlines.

Salmonids are susceptible to numerous bacterial, viral, and fungal diseases. The more common bacterial diseases in New England waters include furunculosis, bacterial kidney disease, enteric redmouth disease, coldwater disease, and vibriosis (USFWS and Gaston 1988; Egusa and Kothekar 1992; Olafesen and Roberts 1993). Furunculosis, which is particularly widespread, can be a significant source of mortality in wild Atlantic salmon populations if river water temperatures become unusually high for extended periods (USFWS and Gaston 1988). Whirling disease is a parasitic infection caused by the microscopic parasite *Myxobolus cerebrali*. Infected fish continually swim in circular motions and eventually expire from exhaustion. The disease occurs both in the wild salmonids and in hatcheries. Saprolegnia is a fungal disease of Atlantic salmon and is primarily found in adult males. It invades the epidermis and is associated with the presence of high levels of androsteroids (USFWS and Gaston 1988; Olafesen and Roberts 1993).

In 1996, the first occurrence of the infectious salmon anemia virus in North America was found in an aquaculture facility in New Brunswick, Canada (Fay et al. 2006). The first outbreak of infectious salmon anemia in the U.S. was reported in 2001 in an aquaculture facility in Cobscook Bay, Maine. Approximately 925,000 fish were removed from aquaculture pens throughout the Bay that year, and eventually all cultured salmon in the Bay had to be removed (Fay et al. 2006). While captive fish have the highest risk for transmission and outbreaks of diseases such as infectious salmon anemia, wild fish that must pass near aquaculture facilities are at risk of encountering both parasites and pathogens from hatchery operations. Although substantial progress has been made in recent years to reduce the risks to wild fish posed by aquaculture, this remains a potential threat.

Coral diseases are believed to be the primary agent of the region-wide decline of Atlantic *Acropora spp.* beginning in the late 1970s (ABRT 2005). Increased seawater temperature and nutrient enrichment also may act synergistically with coral diseases to reduce coral health and survivorship (Bruno et al. 2003; Bruno et al. 2007). White band disease is generally attributed with the majority of disease-related mortality in ESA-listed elkhorn and staghorn coral (Aronson and Precht 2001). White pox disease resulting from the bacterial pathogen *Serratia marcescens* has also resulted in major impacts on elkhorn coral (Patterson et al. 2002).

5.13 Scientific Research and Permits

Many of the ESA-listed species in this opinion are the subject of scientific research and monitoring activities. Research on the ESA-listed species is granted an exemption to the ESA take prohibitions of section 9 through the issuance of section 10(a)(1)(A) permits. In the short term, adverse effects to ESA-listed marine mammals and sea turtles may occur in the course of scientific research. Research activities authorized through scientific research permits can produce various stressors on wild and captive animals resulting from capture, handling, and research procedures. Scientific research permits issued by NMFS are conditioned with mitigation measures to ensure that the impacts of research activities on target and non-target ESA-listed species are as minimal as possible. Research activities have a great potential to benefit ESA-listed species in the long-term. Information obtained from scientific research is essential for understanding the status of ESA-listed species, obtaining specified critical biological information, and achieving species recovery goals.

Currently, there are 24 active sea turtle research permits issued for work in the Atlantic and Gulf of America under the NMFS Sea Turtle Research and Enhancement Permitting Program and covered by the sea turtle research permit programmatic biological opinion (NMFS 2017a). The sea turtle research programmatic established mortality banks for each species, which represent the maximum total number of mortalities that could be authorized and used over each 10-year period. Table 51 shows the sea turtle mortality bank limits, lethal takes authorized, and lethal takes reported in the Atlantic Ocean and Gulf of America. Only two sea turtle lethal takes (Kemp's ridley and loggerhead) have been reported since 2018 when the programmatic opinion took effect.

Table 51. Programmatic Mortality Bank Limits and Takes of Sea Turtles in the Atlantic Ocean and Gulf of America. Bank Limits and Takes are Authorized over 10 years (2018-2027) (NMFS 2024a)

Sea Turtle Species	Mortality Bank Limit	Authorized Lethal Takes	Cumulative Reported Lethal Takes (2018-2027)
Green	10	3	0
Kemp's ridley	10	3	1
Hawksbill	5	1	0
Olive	5	1	0
Leatherback	10	3	0
Loggerhead	10	4	1

In 2017, we completed a programmatic consultation with the Permits Division on the implementation of a new sturgeon research program. Currently, there are 16 active research permits issued for Atlantic and shortnose sturgeon research under the NMFS Sturgeon Research and Enhancement Permitting Program covered by the sturgeon research permit programmatic biological opinion. Scientific research permits authorized under the sturgeon research program

promote sturgeon conservation and recovery, and result in a net benefit to ESA-listed species and DPSs. As a condition of their permit, sturgeon researchers are required to follow specific protocols to avoid, minimize, and mitigate the unintended detrimental effects that may result from research activities such as capture, handling, or performing various invasive procedures. In addition to these standard protocols, as a condition of their permit researchers are required to consider additional precautionary measures to further minimize potential impacts on sturgeon. While these precautionary measures have proven highly effective at reducing detrimental impacts of research, and continue to improve over time, there remains some risk of sturgeon mortality, either (1) “in-hand” mortality as a direct result of capture, handling or performing a procedure, or (2) delayed mortality due to invasive procedures (e.g., surgery, gastric lavage) performed on captured fish. As such, some small amount of lethal take (i.e., mortality) is authorized for Atlantic sturgeon research through established mortality banks. Mortality banks limit the allowable lethal take for each spawning subpopulation based on its estimated abundance and a calculated river system health index. For details on sturgeon research permit mortality bank limits see the NMFS (2017a) programmatic biological opinion.

In 2019, we completed a programmatic consultation with the Permits Division on the implementation of a new sawfish research program, similar to the programmatic consultation completed for sturgeon in 2017. Currently, there are four active research permits issued for smalltooth sawfish research under the NMFS Smalltooth Sawfish Research Permitting Program covered by the 2019 programmatic biological opinion. Since their listing in 2003, only one smalltooth sawfish mortality has been reported as a result of research authorized under a section 10(a)(1)(A) permit. As with sea turtles and sturgeon, mitigation measures implemented by NMFS through permit conditions and additional precautions taken by researchers have significantly reduced the lethal and sublethal effects of research activities on smalltooth sawfish.

In 2019 we completed a programmatic consultation with the Permits Division on the implementation of a new cetacean research and enhancement program. Authorized research on ESA-listed marine mammals includes close vessel and aerial approaches, photographic identification, photogrammetry, biopsy sampling, tagging, ultrasound, exposure to acoustic activities, breath sampling, behavioral observations, passive acoustic recording, and underwater observation. Only nonlethal “takes” of marine mammals are authorized for research activities. For the majority of cetacean research methods proposed, the permit conditions and minimization measures that researchers are required to follow mitigate the risk of fitness-level impacts. However, these minimization measures may not eliminate all risk of fitness level impacts from the use of deep-implantable tags on ESA-listed cetaceans. Therefore, under the programmatic deep-implantable tags will not be authorized for some species or age-classes, and will be limited in the number of tags for those species and populations that may be tagged (NMFS 2019a). For ESA-listed species with declining population trends, the potential for fitness-level impacts can have more significant effects on these populations, and conservatively, the Permits Division will not authorize deep-implantable tags for these species or DPSs. ESA-listed cetacean species

within the action area for which deep-implantable tags may be authorized under the programmatic consultation include blue whales, fin whales, and sperm whales (NMFS 2019a).

5.14 Ongoing Military Readiness Activities

As described in Section 2, the Action Proponents conduct training and testing throughout the action area as part of their military readiness activities. The majority of AFTT activities conducted in the action area are similar, if not identical, to activities that have been occurring in the same locations for decades and are covered under several range-specific biological opinions (NMFS 2018a). For this reason, ongoing Action Proponent training and testing activities in the action area are mentioned here as part of the environmental baseline.

In 2018, NMFS issued a biological and conference opinion (with revised ITS issued in October 2019) on the U.S. Navy Atlantic Fleet's military readiness training and testing activities (AFTT) and the promulgation of regulations for incidental take of marine mammals (NMFS 2018a). We concluded that the action is not likely to jeopardize the continued existence of any ESA-listed species or result in destruction or adverse modification of critical habitat. The AFTT Phase III opinion includes an ITS with exempted take for ESA-listed marine mammals, sea turtles, fish, and coral (for details see <https://repository.library.noaa.gov/view/noaa/31540>). Through the section 7 consultation process with NMFS, the Navy has implemented monitoring and conservation measures to reduce the potential effects of explosives, sonar, and vessel strikes on ESA-listed resources in the Atlantic Ocean and Gulf of America.

In addition to training and testing activities, the Navy has consulted with NMFS for on-going activities in portions of the action area including the cleanup of former Naval stations on the main island of Puerto Rico (Ceiba) and on the island of Vieques. The USACE, which is the agency responsible for the cleanup of areas designated as Formerly Used Defense Sites, is currently consulting with NMFS for cleanup activities in and around Desecheo Island and Culebra Island and its associated islands and cays. A programmatic ESA section 7 consultation was completed in 2020 for activities associated with the removal of unexploded ordnance. These consultations concluded that there could be adverse effects to ESA-listed corals and their habitat due to underwater cleanup activities.

The Air Force conducts training and testing activities on range complexes on land and in U.S. waters in the action area. Aircraft operations and air-to-surface activities may occur in the action area (e.g., off Florida). Air Force activities generally involve the firing or dropping of munitions (e.g., bombs, missiles, rockets, and gunnery rounds) from aircraft towards targets located on the surface, though Air Force training exercises may also involve boats. These activities have the potential to impact ESA-listed species by physical disturbance, boat strikes, debris, ingestion, and effects from sound and pressure produced by detonations. Air Force training and testing activities constitute a Federal action and take of ESA-listed species considered for these Air Force activities have previously undergone separate section 7 consultations. NMFS has completed section 7 consultations on Eglin Air Force Base testing and training activities in the Gulf of America. These opinions have issued incidental take of ESA-listed species for the

following actions: Eglin Gulf Test and Training Range (NMFS 2004b), the Precision Strike Weapons Tests (NMFS 2005b), the Santa Rosa Island Mission Utilization Plan (NMFS 2005c), Naval Explosive Ordnance Disposal School (NMFS 2004a), Eglin Maritime Strike Operations Tactics Development and Evaluation (NMFS 2013a), and Ongoing Eglin Gulf Testing and Training Activities (NMFS 2017b). In April 2023, NOAA published a final rule pursuant to the MMPA regulating the incidental take of marine mammals to testing and training activities conducted in the Eglin Gulf Testing and Training Range from 2023 to 2030 (88 FR 24058; 50 CFR § 218). As part of the final rule, conservation provisions include restricting live munitions at certain distance setbacks from the 100 m isobaths for Rice's whale, and prohibiting inert munitions in areas that fall within the proposed Rice's whale critical habitat area.

5.15 The Impact of the Environmental Baseline on ESA-Listed Resources

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed resources considered in this consultation. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, whaling, entanglement in fishing gear), whereas others result in more indirect (e.g., impacts to habitat) or non-lethal impacts (e.g., auditory injury). Assessing the aggregate impacts of these stressors on species is difficult and, to our knowledge, no such analysis exists. This becomes even more difficult considering that many of the species in this opinion are wide ranging and subject to stressors in locations throughout the action area and outside the action area.

We consider the best indicator of the aggregate impact of the Environmental Baseline on ESA-listed resources to be the status and trends of those species. As noted in Section 4.2.1, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the Environmental Baseline is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the Environmental Baseline. Therefore, while the Environmental Baseline may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the Environmental Baseline is preventing their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historic commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself.

6 ANALYSIS OF EFFECTS

The ESA section 7 regulations (50 CFR §402.02) define effects of the action as: *“all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but*

for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action.”

To understand the effects of the action to ESA-listed species and critical habitats, we employ a stressor-exposure-response analysis. The stressors resulting from the proposed action were identified in Section 2.4. In Section 4.1.1, we discussed those stressors that are NLAA for any ESA-listed species. The remaining stressors, which we will analyze in this section for each species (where appropriate), are:

- 1) Acoustic stressors from sonar and other transducers;
- 2) Acoustic stressors from air guns;
- 3) Explosive stressors in water;
- 4) Physical disturbance and strike stressors from vessels.

Our analysis of the effects of the stressors listed above is organized in this section by species group (i.e., marine mammals, sea turtles, fish, and invertebrates) because, in general, we expect species within each group to respond in similar ways to these stressors. Where different responses by a species or subgroup (e.g., mysticetes versus odontocetes) within a species group have been identified or documented in the literature, we discuss those differences in our analysis and consider them in our effects determinations.

The following analysis is structured to first assess the exposure of ESA-listed species to the stressors above, followed by a separate assessment of the responses of ESA-listed species to that exposure. At the end of this section we provide a table summarizing all of our effects determinations for each stressor category and ESA-listed species/critical habitat combination (see Table 74).

6.1 Marine Mammals

This section addresses the effects of acoustics (from sonar and other transducers and air guns), in-water explosives, and vessel strike stressors on ESA-listed marine mammals. We start with an overview of the methodology for the Navy’s quantitative analysis of the effects of sonar, air guns, and explosives from training and testing activities on marine mammals.

6.1.1 Acoustic and Explosive Effects Analysis

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

To estimate impacts from acoustic stressors associated with the proposed training and testing activities, the Navy performed a quantitative analysis to estimate the number of instances that could affect ESA-listed marine mammals and the magnitude of that effect (e.g., injury, hearing

loss, behavioral response). The quantitative analysis utilizes the Navy's Acoustic Effects Model (NAEMO) and takes into account criteria and thresholds used to predict impacts in conjunction with spatial densities of species within the action area.

An overview of the quantitative analysis approach is provided below. A more detailed explanation of this analysis can be found in the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase IV Training and Testing* (Navy 2024h). NMFS verified the methodology and data used by the Navy in this analysis and, unless otherwise specified in this opinion, we accept the Navy's quantitative analysis on exposure of marine mammals and sea turtles to sound generated by the proposed action. We consider the modeling conclusions from this analysis to represent the best available data on exposure of marine mammals and sea turtles to acoustic stressors from the proposed action, and the estimated impacts (e.g., mortality, non-auditory injury, AINJ, TTS, and significant disruption of behavior) resulting from this analysis are reasonably certain to occur. Although not incorporated into NAEMO, activity-based mitigation measures (described in Section 2.3.2, Table 5, Table 6, and Table 7) may further reduce the number and severity of marine mammal exposures to AFTT acoustic and explosive stressors.

Navy Acoustic Effects Model (NAEMO)

NAEMO is used to assess the level of behavioral disturbance and physiological impacts (e.g., TTS and AINJ) predicted for individual marine mammals and turtles likely to be in the vicinity of training and testing activities due to the emission of sounds and impulses. NAEMO calculates sound energy propagation from sonars and other transducers (as well as airguns and explosives) during naval activities and the sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals distributed in the area around the modeled naval activity. Each of the animat dosimeters records its individual sound "dose." The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances during which marine mammals may be exposed to sound levels resulting in an effect. Therefore, the model estimates the annual number of exposures that may result in each type of effect but does not estimate the number of individual marine mammals that may be affected. Some individuals may be exposed more than once per year but the model does not estimate whether a single individual is exposed multiple times.

Marine mammal data input to the NAEMO include densities, group size, stock estimates, and depth distribution. Marine mammals are distributed within the action area with multiple iterations generated for each species to account for statistical uncertainty in the density estimates. Because many marine mammals are known to travel and feed in groups, species-specific group sizes are incorporated into animat distributions. Species-specific group sizes are estimated using literature review, survey data, and density data, and uncertainty of group size estimates are statistically represented by the standard deviation. The model bases the distribution of animats over the action area on the density values in the *U.S. Navy Marine Species Density Database Phase IV for the AFTT Study Area* (Navy 2024j), and distributes animats in the water column proportional to the known time that species spend at varying depths. NAEMO accounts for depth

distributions by changing the depth of each animat during the simulation process according to the typical depth pattern observed for each species. Depth distribution information was collected by a literature review and is presented as a percentage of time the animal typically spends at each depth in the water column. Dive profiles for each species are provided in the Navy technical report *Dive Distribution and Group Size Parameters for Marine Species Occurring in the U.S. Navy's Atlantic and Hawaii-California Training and Testing Study Areas* (Navy 2024f).

Physical environment data plays an important role in acoustic propagation of underwater sound sources used in the impact modeling process (Navy 2024h). Physical environment parameters that influence propagation modeling include bathymetry, seafloor composition/sediment type, wind speed, and sound speed profiles. NAEMO accounts for environmental variability in sound propagation with both distance and depth, as well as boundary interactions, when computing the received sound level of the animats. The model conducts a statistical analysis based on multiple model runs to compute the potential acoustic effects on animals. The number of animats for which the thresholds of effects is exceeded is tallied to estimate the number of times marine mammals could be affected by the aspects of the proposed activity that generate sound (Navy 2024h).

The model estimates the impacts caused by individual training and testing events. Each modeling scenario is connected to a modeling area to create a modeling event. The platforms within the scenario are randomly distributed throughout the modeling area. The modeling areas can be quite large (i.e., range complexes and operation areas) and platforms included in the same modeling event are intended to interact during the exercise. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. A Monte Carlo simulation approach which involves repeated random sampling is used to account for the variability inherent in many factors of training and testing events, such as the precise location of modeling area, platform location and movement, and instantaneous distributions of marine mammals (Navy 2024h).

The Navy, with input from NMFS, has continually sought to update and improve on NAEMO. The notable changes to the model from Phase III to the Phase IV include (Navy 2024h):

- Updated density estimates and environmental data based on the best available science.
- The acoustic source binning process has been updated to more accurately group similar sources and use the parameters of the bin for propagation.
- Non-impulsive broadband sources were binned into broadband source bins and broken out into sub-bins at every octave within the frequency range. Non-impulsive sources are considered broadband in NAEMO if the bandwidth spans more than two octaves. Each sub-bin was propagated and simulated separately, more accurately capturing the frequency spectrum associated with these sources. In Phase III, broadband sources were modeled at a single frequency, the geometric mean of the low and high range, which did not provide as comprehensive a representation of the frequency profile.
- An animal avoidance process was developed and integrated into NAEMO for marine mammals. "Avoidance" refers to a marine mammal avoiding a high-intensity sound

exposure by moving horizontally out of the immediate injury zone for subsequent exposures. The onset of avoidance was based on the behavioral response functions. Avoidance speeds and durations were informed by a review of available exposure and baseline data. This process reduces SEL accumulation for a given animal (virtual animal) by reducing the received SPL of individual exposures based on a spherical spreading calculation from sources on each unique platform in an event. The SEL reduction could lower an animal's calculated value below the TTS or AINJ species-specific threshold, reducing the total number auditory effects. An avoidance factor was only calculated for non-impulsive source (e.g., sonar and transducers) modeling but could not be used for impulsive modeling due to a lack of data on certain source count spacing. In Phase III avoidance was not modeled in NAEMO. Instead, 95% of the PTS, now referred to as AINJ, predicted by NAEMO were assumed to be reduced to TTS due to avoidance (no further reduction below TTS was calculated for Phase III).

- The similitude equation used for impulsive modeling has been updated to reflect the most current version applicable for underwater explosions.

Density Estimates

For most cetacean species, abundance is estimated using line-transect surveys or mark-recapture studies. The result provides one single density estimate value for each species across broad geographic areas. This is the general approach applied in estimating cetacean abundance in NMFS' marine mammal SARs. Although the single value provides a good average estimate of abundance (total number of individuals) for a specified area, it does not provide information on the species distribution or concentrations within that area, and it does not estimate density for other timeframes or seasons that were not surveyed. More recently, habitat modeling has been used to estimate cetacean densities. These models estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow predictions of cetacean densities on finer spatial scales than traditional line-transect or mark recapture analyses. Within the geographic area that was modeled, densities can be predicted wherever these habitat variables can be measured or estimated. For Phase IV, marine mammal density models were developed by Roberts et al. (2023) for the East Coast and AFTT strata, and by the SEFSC for the Gulf of America stratum as part of the Gulf of Mexico Marine Assessment Program for Protected Species (Garrison et al. 2023a; Rappucci et al. 2023).

To characterize the marine species density for large areas such as the AFTT action area, the Navy compiled data from several sources. The Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the Navy Marine Species Density Database (NMSDD) includes seasonal density values for every marine mammal species present within the AFTT action area. This database is described in the technical report titled *U.S. Navy Marine Species Density Database Phase IV for the Atlantic Fleet Training and Testing Area* (Navy 2024j), hereafter referred to as the density technical report.

Criteria and Thresholds

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

Non-auditory Injury and Mortality

The Navy’s quantitative analysis assessed the potential for AFTT activities involving in-water explosives to physically injure or kill marine mammals. The effects of underwater explosions on marine mammals depend on a variety of factors including animal size and depth; charge size and depth; depth of the water column; and distance between the animal and the charge. The gas-containing organs (lungs and gastrointestinal tract) are most vulnerable to primary blast injury. Severe injuries to these organs are presumed to result in mortality (e.g., severe lung damage may introduce air into the cardiopulmonary vascular system, resulting in lethal air emboli) (Navy 2024e).

Two metrics are used to assess injurious exposures to explosives: peak pressure and impulse. The impulse criterion relies on two variables: the mass of an animal (M) and its depth (D) below the water surface. The impulse is calculated over the lesser of the duration of the initial positive pressure or 20% of the estimated lung resonance period (Navy 2024e). In Phase IV, the thresholds for non-auditory injury and mortality are anchored to the lowest exposures with an effect observed in the underlying experimental data sets, rather than the mean value as in Phase III. The criteria used for Phase IV follow a similar methodology as past Navy explosive impact analyses (Finneran and Jenkins 2012; Navy 2017). Table 52 compares the Phase III and Phase IV thresholds for mortality and injury.

Table 52. Comparison of Phase III and Phase IV Mortality and Injury Thresholds

Impact Category	Phase III	Phase IV
Mortality (Impulse)	$144M^{1/3} \left(1 + \frac{D}{10.1}\right)^{1/6}$ Pa-s	$103M^{1/3} \left(1 + \frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury (Impulse)	$65.8M^{1/3} \left(1 + \frac{D}{10.1}\right)^{1/6}$ Pa-s	$47.5M^{1/3} \left(1 + \frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury (Peak Pressure)	243 dB re 1 μPa SPL peak	237 dB re 1 μPa SPL peak

Notes: dB re 1 μPa: decibels referenced to 1 micropascal; Pa-s: pascal second; SPL: sound pressure level; D: depth of animal (m); M: mass of animal (kilograms).

Auditory Impacts

Exposure to sound with sufficient duration and SPL may result in an elevated hearing threshold (i.e., a loss of hearing sensitivity), called a noise-induced threshold shift (NITS). If the hearing threshold eventually returns to normal, the NITS is called a TTS; otherwise, if thresholds remain elevated after some extended period of time, the remaining NITS is called a PTS.

The Navy, in coordination with NMFS, established marine mammal acoustic thresholds that identify the received level of underwater sound above which exposed marine mammals would reasonably be expected to experience a potentially significant disruption in behavior, or to incur some degree of TTS or AINJ (which includes PTS). Thresholds have also been developed to identify the pressure levels above which animals may incur different types of tissue damage from exposure to pressure waves from explosive detonation. A detailed description of the marine mammal criteria and threshold development is included in the Navy's technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase IV)* (Navy 2024e). The thresholds used as inputs to NAEMO were developed by compiling and synthesizing the best available scientific information on the susceptibility of marine mammals to effects from acoustic exposure.

The marine mammal criteria and thresholds for non-impulsive and impulsive sources for hearing impairment, non-auditory injury, and mortality, as applicable, are described below. The Navy's quantitative acoustic effects analysis used dual criteria to assess impacts to different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources: impulsive (e.g., in-water explosives and air guns) and non-impulsive (e.g., sonar and other transducers).

Marine mammals were divided into groups for analysis. For purposes of the Phase IV NAEMO analysis, group names were changed from Phase III to be consistent with Southall et al. (2019b). The low-frequency cetacean group (i.e., mysticetes) was split into two groups (i.e., very-low-frequency group and low-frequency group²²) with the upper hearing limit for the LF group increased from Phase III to match recent hearing measurements in minke whales (Houser et al. 2024). Houser et al. (2024) temporarily held two adolescent minke whales in pens for hearing tests, which showed that minke whales are sensitive to sound frequencies as high as 45 to 90 kHz. This study challenged the long-standing notion that all mysticetes are low-frequency hearing specialists. For Phase IV, the mid-frequency cetacean group is now designated as the high-frequency cetacean group; and the group previously designated as high-frequency cetaceans is now the very-high frequency cetacean group. The three groups relevant to the effects analysis for the ESA-listed species considered in this consultation are: very-low frequency (VLF)

²² Note: This approach differs from NMFS's 2024 Update to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing NMFS. 2024g. Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0): Underwater and In-Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts. U.S. Dept. of Commerce, NOAA., which considers all baleen whales as part of the low frequency cetacean hearing group.

cetaceans (e.g., fin, blue and North Atlantic right whales); low-frequency (LF) cetaceans (e.g., sei and Rice's whales); and high-frequency (HF) cetaceans (e.g., sperm whales).

The Navy's acoustic impact analyses uses auditory weighting functions to capture the frequency dependent nature of the effects of noise. Auditory weighting functions are mathematical functions used to emphasize frequencies where animals are more susceptible to noise exposure and deemphasize frequencies where animals are less susceptible. A frequency-dependent weighting function (Figure 54) and numeric thresholds for the onset of temporary threshold shift (TTS) and the onset of auditory injury (AINJ) were estimated for each marine mammal hearing group. New weighting functions and TTS/AINJ thresholds were developed for Phase IV based on the availability of new data regarding marine mammal hearing and the effects of noise on marine mammal hearing.

The onset of TTS is defined as a TTS of 6 dB measured approximately two to five minutes after exposure. A TTS of 40 dB is used as a proxy for the onset of AINJ, which include PTS. For non-impulsive exposures, onset levels are specified in frequency-weighted SEL; for impulsive exposures, dual metrics of weighted SEL and unweighted peak SPL are used.

Figure 55 and Figure 56 compare exposure functions across species groups, for non-impulsive and impulsive exposures, respectively.

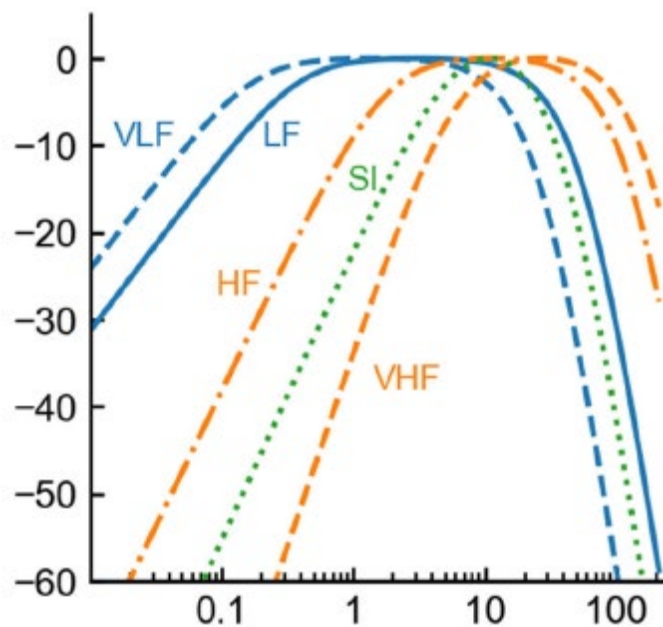


Figure 54. Navy Phase IV Weighting Functions by Species Group (amplitude in dB on y-axis; frequency in kHz on x-axis)

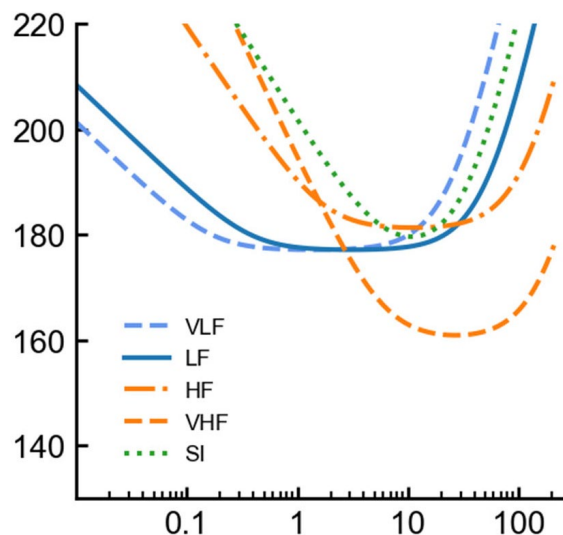


Figure 55. Comparison of Navy Phase IV TTS Exposure Functions for Sonars and Other Non-impulsive Active Acoustic Sources across Species Groups (exposure SEL in dB on y-axis; frequency in kHz on x-axis)

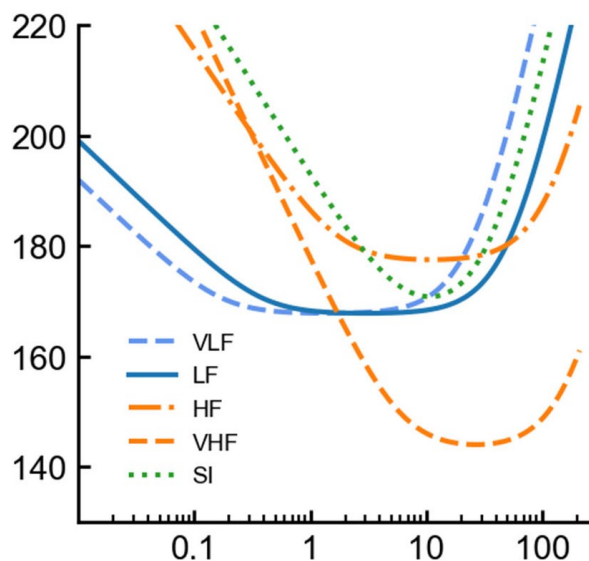


Figure 56. Comparison of Navy Phase IV TTS Exposure Functions for Explosives, Impact Pile Driving, Air Guns, and Other Impulsive Acoustic Sources Across Species Groups (exposure SEL in dB on y-axis; frequency in kHz on x-axis)

Table 53 summarizes the weighted TTS and AINJ thresholds by source type (i.e., impulsive and non-impulsive) and by cetacean group (i.e., VLF-very low frequency, LF-low frequency, and HF-high frequency).

Table 53. Summary of Phase IV TTS/AINJ Thresholds (SEL thresholds are in dB re 1 μ Pa2s underwater)

Group	Non-impulsive TTS threshold SEL (weighted)	Non-impulsive INJ threshold SEL (weighted)	Impulsive TTS threshold SEL (weighted)	Impulsive TTS threshold peak SPL (unweighted)	Impulsive INJ threshold SEL (weighted)	Impulsive INJ threshold peak SPL (unweighted)
VLF	177	197	168	216	183	222
LF	177	197	168	216	183	222
HF	181	201	178	224	193	230

Behavioral Response Criteria

For their Phase IV analysis the Navy updated the criteria and numeric thresholds for predicting marine mammal behavioral responses when exposed to non-impulsive sources and impulsive sources. Behavioral response functions were developed to estimate numbers of animals that could exhibit significant behavioral responses to Navy training and testing activities. The term “significant behavioral response” is used by the Navy to describe behavioral observations that may rise to the level of “Level B harassment” under the MMPA. Under the MMPA, for military readiness activities such as Action Proponent training and testing, Level B harassment is defined as “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” (Section 315(f) of Public Law 107–314; 16 U.S.C. 703 note)²³.

Responses reported from all marine mammal behavioral response and controlled exposure studies were included in the analysis. Responses were scored and response significance was determined based on a behavioral response severity scale (i.e., low, moderate, or high) derived from Southall et al. (2021) as follows:

²³ By comparison, NMFS’s 2023 policy directive on the term “harass” under the ESA defines it as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering” NMFS. 2016a. Interim Guidance on the Endangered Species Act Term “Harass.” December 2016. Protected Resources Management. National Marine Fisheries Service Procedural Instruction 02-110-10. , NMFS. 2023h. Protected Species Management, Conservation of Threatened And Endangered Species Policy Directive 02-110: Guidance on the Endangered Species Act Term “Harass” NMFS Office of Protected Resources.

- Low severity responses are within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned.
- Moderate severity responses could become significant if sustained over a longer duration. For the derivation of the Navy's behavioral criteria, a long duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long that exposure lasted.
- High severity responses include those with immediate consequences (e.g., stranding) and those affecting animals in vulnerable life stages (i.e., calf, pup, or cub), and are therefore always considered to be a significant behavioral reaction.

Marine mammals were divided into four groups for this analysis, two of which include species considered in this opinion (i.e. mysticetes and odontocetes). For each group, to estimate the impacts from non-impulsive sources (including Navy sonar), a biphasic behavioral response function was developed using best available data and Bayesian dose response models (Figure 57 and Figure 58). Compared to Phase III, the odontocete behavioral response function is less sensitive in Phase IV. Similarly, the mysticete curve in Phase IV is less sensitive at higher received levels than the general mysticete curve from Phase III.

To estimate the significant behavioral response impacts from explosives, if more than one explosive event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have a behavioral reaction. For events with multiple explosions, the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold. This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulse TTS testing (Schlundt et al. 2000). For single explosions at received sound levels below hearing loss thresholds, the modeled assumption is that significant behavioral reactions would not be expected to occur (i.e., either low severity responses or short-term moderate severity responses would be expected).

There is empirical evidence to suggest animals are not likely to exhibit behavioral response when exposed to low levels of sound from a source that is far away (Navy 2024e). To account for this in Phase IV, NAEMO has implemented behavioral cutoffs that consider both received sound level and distance from the source. These cutoffs are unique to each behavioral hearing group. For mysticetes the modeled cutoff was 10 km with a received level of 185 dB RMS; i.e. animals that are beyond 10 km from the source and below 185 dB re 1 μ Pa RMS are unlikely to incur significant behavioral reactions. For odontocetes the modeled cutoff was 15 km with a received level of 168 dB RMS; i.e., animals that are beyond 15 km from the source and below 168 dB re 1 μ Pa RMS are unlikely to incur significant behavioral reactions. For both mysticetes and odontocetes, regardless of received level, the model considered animals beyond 100 km from the source as unlikely to incur significant behavioral responses.

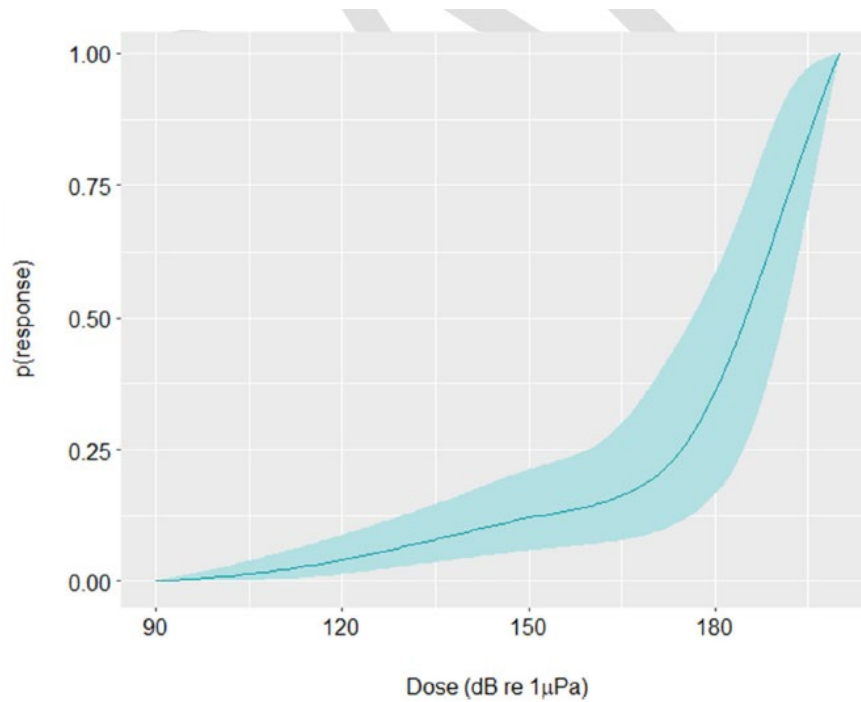


Figure 57. Phase IV Mysticete Biphasic Behavioral Response Function (50% credible interval shaded in teal)

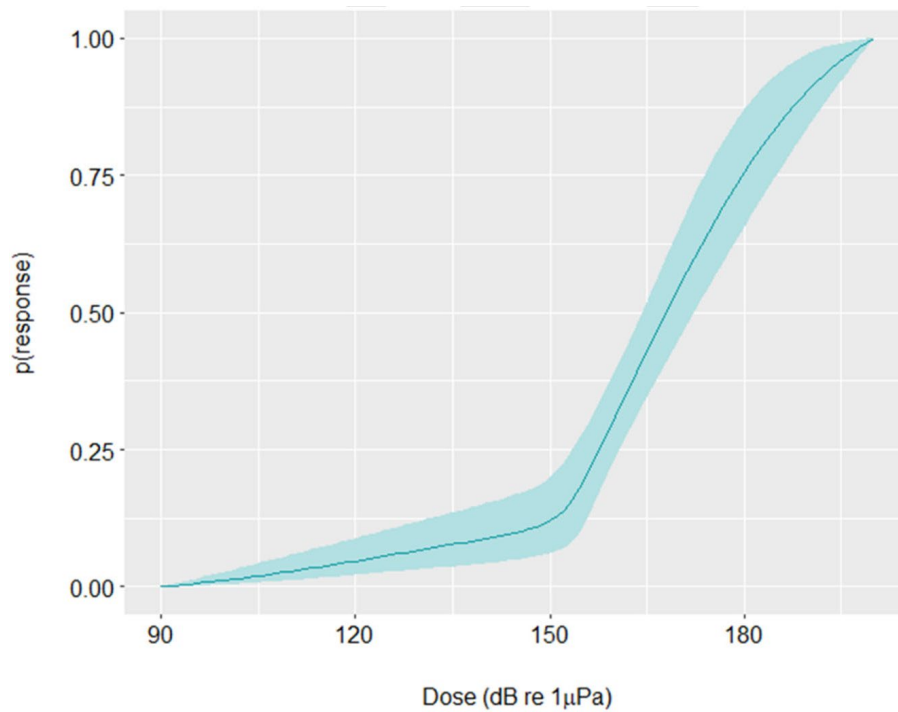


Figure 58. Phase IV Odontocete Biphasic Behavioral Response Function (50% credible interval shaded in teal)

Ranges to Effects

A “range to effect” is the distance from where a source is used to the furthest distance at which an effect would be expected to occur. Ranges to effects are used to help predict impacts from acoustic and explosive sources and assess the benefit of mitigation zones (Navy 2024c). Ranges are determined by modeling the distance that noise from a source will need to propagate to reach exposure level thresholds specific to a hearing group that will cause a significant behavioral response, TTS, AINJ, non-auditory injury, or mortality. This value depends on several factors including: source bin parameters (frequency, sound level, pulse length, pulse interval); source exposure parameters (duration for sonar, cluster size for explosives); source origin (latitude, longitude, depth, time of year); source directionality (bearing); species dive profile; and species effect criteria. New for Phase IV, the Navy used species dive profiles when computing ranges-to-effects. In Phase III only the maximum dive depth of the species was used and an even dive profile (constant for all depths) was assumed. The ranges shown below do not account for an animal avoiding a source nor for the movement of the platform, both of which would influence the actual range to onset of auditory effects during an actual exposure (Navy 2024c).

Ranges to effects to marine mammals from exposure to sonar and other transducers, airguns, and explosives are provided in the Atlantic Fleet Training and Testing Final Supplemental EIS/OEIS: *Appendix E. Acoustic and Explosive Impacts Analysis for Marine Mammals, Reptiles, and Fishes in the Atlantic Fleet Training and Testing Study Area* (Navy 2025b), and are incorporated into this opinion by reference (Section 2.5, pp. 2-150 through 2-196). For sonar and other transducers, ranges to TTS and AINJ are shown by functional hearing group (i.e., VHF, HF, LF, VLF) for four different exposure durations (i.e., 1, 30, 60, and 120 seconds) for the following six representative sonar systems: hull-mounted surface ship sonar (MF1); hull-mounted surface ship sonar (MF1K – Kingfisher mode); hull-mounted surface ship sonar (MF1C – duty cycle > 80%); helicopter dipping sonar; sonobuoy sonar; and towed mine-hunting sonar. For each sonar system, behavioral response curves are provided showing the probability of a behavioral response (i.e., mean, 5th, and 95th percentile) as a function of range (km) from the sound source by behavioral response group: sensitive species, mysticete, odontocete, and pinniped (note: only mysticete and odontocete groups relevant for this consultation).

For explosives, ranges are provided for a representative cluster size for each bin. Ranges for behavioral response are only provided if more than one explosive cluster occurs. Single explosions at received sound levels below TTS and AINJ thresholds are most likely to result in a brief alerting or orienting response. Due to the lack of subsequent explosions, a significant behavioral response is not expected for a single explosive cluster (Navy 2024c). For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and AINJ based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure-based ranges are estimated using the best available science; however, data on peak pressure at far distances from

explosions are very limited. The explosive ranges to effects for TTS and AINJ that are in the tables are based on the metric (i.e., SEL or SPL) that produced longer ranges (Navy 2024c). For non-auditory injury in the tables, the larger of the range to slight lung injury or gastrointestinal tract injury was used as a conservative estimate (Navy 2024c). Since the non-auditory metric is SPL-based, ranges are only available for a cluster size of one. Animals within water volumes encompassing the estimated range to non-auditory injury would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point (Navy 2024c).

Exposure Analysis

The criteria and thresholds section (above) presented information to estimate impacts to marine mammals from acoustic and explosive stressors. Additional information on these criteria is described in the Navy's criteria and thresholds technical report (Navy 2024e). This section presents information on the estimated number of exposures of ESA-listed marine mammals to acoustic (i.e., sonar and other transducers, and air guns) and explosive stressors that are expected to result in a significant behavioral response, TTS, AINJ, non-auditory injury, or mortality. Exposure estimates were produced using the Navy's NAEMO approach as described above, and in more detail in the Navy's technical report (Navy 2024h).

Exposure impacts are assigned to the highest order threshold exceeded at the animal (i.e., non-auditory injuries are assumed to outrank auditory effects, and auditory effects are assumed to outrank significant behavioral responses) (Navy 2024e). In all instances any auditory impact or injury is assumed to represent a concurrent significant behavioral response. For example, if a significant behavioral response and TTS are predicted for the same animal in a modeled event, the effect is counted as a TTS in the table.

The summation of instances of effect includes all fractional values caused by averaging multiple modeled iterations of individual events. Impacts are only rounded to whole numbers at the level of substressor and type of activities. Rounding follows standard rounding rules, in which values less than 0.5 round down to the lower whole number, and values equal to or greater than 0.5 round up to the higher whole number (Navy 2024e).

The impacts tables below for each ESA-listed marine mammal include five sections, each representing a different way to analyze impacts.

- The first section shows the number of instances of each effect type that could occur due to each substressor (sonar, air guns, or explosives) and type of activity (U.S. Navy training activities, U.S. Coast Guard training activities, or Navy testing activities) over a maximum year of activity. Maximum year impacts are based on modeling the maximum proposed annual activity levels for each acoustic or explosive stressor. In cases where the model predicts less than one impact per year, on average (e.g., one TTS every seven years), the estimated number of impacts in the maximum year would be one.
- The second section estimates the average number of times an individual in the stock would be affected. The average annual impacts per individual is the sum of all instances

of effect divided by the population abundance estimate. As noted previously, the number of instances of effect is not the same as the number of individuals that could be affected, as some individuals in a stock could be affected multiple times, whereas others may not be affected at all. The population abundance estimate used to calculate this average was derived as the greater value of the following: 1) the best population estimate from the SAR prepared by NOAA (Hayes et al. 2022; Hayes et al. 2023), or 2) the average abundance predicted by the NMSDD (Navy 2024j) within the U.S. EEZ. These values are shown in Table 54 for stocks with modeled impacts in the action area.

- The third section shows the percent of total impacts that would occur within seasons and the following general geographic areas: Northeast (Atlantic waters north of New Jersey); Mid-Atlantic (Atlantic waters from New Jersey to North Carolina); Southeast (Atlantic waters from South Carolina to Florida); Key West (areas around the southernmost portion of Florida); Gulf of America; and High Seas (areas of the Atlantic east of the range complexes, generally outside of the U.S. EEZ).
- The fourth section shows which military readiness activities are most impactful to a species. Activities that cause 5% or more of total impacts to a stock are shown.
- The fifth section shows the number of impacts within critical habitat (if designated for the species) and within identified Biologically Important Areas (BIAs), which represent areas and times where marine mammal species are known to concentrate for activities related to reproduction, feeding, and migration, as well as the known ranges of small and resident populations.

Table 54. Estimated Abundances of ESA-Listed Stocks Present in the AFTT Action Area (Navy 2024e)

<i>Species</i>	<i>Stock</i>	<i>SAR¹</i>	<i>NMSDD in EEZ²</i>
Blue whale	Western North Atlantic	402 ³	19 ⁴
Fin whale	Western North Atlantic	6,802	1,075 ⁴
North Atlantic right whale	Western	372 ⁵	216
Rice's whale	Northern Gulf of Mexico	51	118
Sei whale	Nova Scotia	6,282	316 ⁴
Sperm whale	North Atlantic	5,895	4,242
Sperm whale	Northern Gulf of Mexico	1,180	1,614

¹ Best abundance estimate from the SAR (Hayes et al. 2023) is used unless otherwise noted.

² See the Navy *Density Technical Report* for additional information.

³ The abundance shown is the minimum abundance value from the SAR because no 'Best' estimate is provided.

⁴ This abundance estimate from the NMSDD within the EEZ is much lower than the overall population abundance because the range of the stock exceeds the EEZ boundary. See the *Density Technical Report* for additional information.

⁵ From Linden (2024a) NOAA Technical Memorandum.

North Atlantic Right Whale

Estimated exposures resulting in adverse effects to North Atlantic right whales from the use of sonar, air guns, and in-water explosives as part of the proposed action are shown in Table 55.

Table 55. Estimated Acoustic and Explosive Effects to North Atlantic Right Whales over a Maximum Year of Proposed Activities (Navy 2024a)

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>	
Air gun	Navy Testing	0	-	-	-	-	
Explosive	Navy Training	14	10	0	-	-	
Explosive	Navy Testing	6	3	0	-	-	
Explosive	USCG Training	0	0	-	-	-	
Sonar	Navy Training	17	56	(1)	-	-	
Sonar	Navy Testing	71	236	1	-	-	
Sonar	USCG Training	1	-	-	-	-	
Maximum Annual Total		109	305	2	-	-	
<i>Population Abundance Estimate</i>		<i>Annual Impacts per Individual</i>		<i>Annual Injurious Impacts per Individual</i>			
372		1.12		0.01			
<i>Percent of Total Impacts</i>							
<i>Season</i>	<i>Northeast</i>	<i>Mid-Atlantic</i>		<i>Southeast</i>			
Winter	21%	13%		6%			
Spring	37%	7%		1%			
Summer	3%	0%		0%			
Fall	9%	2%		1%			
<i>Activities with 5% or More of Total Impacts</i>				<i>Category</i>	<i>Percent of Total Impacts</i>		
Acoustic and Oceanographic Research (ONR) ¹				Navy Testing	25%		
At-Sea Sonar Testing				Navy Testing	18%		
Mine Countermeasure Technology Research				Navy Testing	13%		
Unmanned Underwater Vehicle Testing				Navy Testing	8%		
<i>Area Type</i>	<i>Area Name (Active Months)</i>		<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Critical Habitat	Northeast US (Foraging) (All)		17	73	0	-	-
Critical Habitat	Southeast US (Calving) (All)		4	2	-	-	-
Draft BIA II	Great South Channel/Georges Bank Shelf Break (4,5,6)		4	19	0	-	-
Draft BIA II	Gulf of ME Mating (11,12,1)		0	2	-	-	-
Draft BIA II	Migratory Corridor (3,4,11,12)		45	128	1	-	-
Draft BIA II	Scotian Shelf (6,7,8)		2	3	-	-	-
Draft BIA II	Southeast Atlantic Calving (1,2,3,11,12)		7	25	0	-	-
Draft BIA II	Southern New England (All)		9	42	0	-	-

BEH = Significant Behavioral Response, TTS = Temporary Threshold Shift, AINJ = Auditory Injury, INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

¹ Modeled sources with specific narrow frequency ranges and high source level that produced AINJ in the preliminary modeling for the Acoustic and Oceanographic Research activity will not be employed during fall and winter seasons in Narragansett OPAREA. This seasonal difference in the proposed activity is included in these final modeled impacts.

Most impacts would occur in the Northeast in the spring and winter, when North Atlantic right whales have a higher density at feeding grounds located near and south of Cape Cod (Navy 2024a). In comparison to impacts in other parts of their range, there would be fewer impacts to North Atlantic right whales in identified calving habitat, including critical habitat in the Southeast. In the summer and fall, there would be few impacts since North Atlantic right whales are more likely to be on the feeding grounds north of the Northeast Range Complexes.

Most predicted impacts are TTS resulting from low and mid-frequency sonar systems used in testing activities in the northeast (Navy 2024a). Impacts from explosives would be limited, and impacts from air guns would be negligible. The risk of auditory injury from testing explosives

and training sonar is low (less than one) in any given year, but one auditory injury is shown for each in a maximum year of impacts due to summing risk across seven years (Navy 2024a). Over the 7-year MMPA authorization period, NAEMO estimates a total of eight AINJ exposures for North Atlantic right whales: two from Navy training with sonar; and six from Navy testing with sonar (Navy 2024a).

We expect the impacts to North Atlantic right whales to be primarily on juveniles and adults, either while foraging in the Northeast region or during seasonal migrations along the Atlantic coast. A smaller number of neonates and calves (i.e., mother-neonate/calf pairs) are also likely to be exposed while they are occupying the breeding and nursing habitat in the southeast U.S. Seven significant behavioral responses and 25 TTS exposures are predicted annually with the Southeast Atlantic calving draft BIA in a maximum year of activity. A subset of these exposures within the draft BIA are predicted to occur within the Southeast calving critical habitat unit (i.e., four significant behavioral responses and two TTS). Based on photo identification data from the North Atlantic Right Whale Consortium Database, in our AFTT Phase III opinion (NMFS 2018a) we estimated that approximately 15% of right whales sighted in these calving areas would be calving females. Based on this information, we estimate that, of the predicted impacts within right whale calving draft BIA, approximately one significant behavioral responses and four TTS would affect mother-calf pairs annually during a maximum year of AFTT activity.

Rice's Whale

Estimated exposures resulting in adverse effects to Rice's whales from the use of sonar and explosives as part of the proposed action are shown in Table 56. Most sonar impacts are due to unmanned underwater vehicle testing, which may use sonar systems at a variety of frequencies for multiple hours most days of the year on the testing range (Navy 2024a). Estimated impacts from explosives would be limited, and there are no estimated impacts from air guns. Impacts are most likely to occur in the winter when Rice's whale densities are predicted to be highest in the northeastern Gulf of America. Unlike most large whales, Rice's are not migratory but rather resident to the Gulf of America, so the risk of repeated impacts on individuals is likely similar within the population as animals move throughout their range. The risk of a single auditory injury from training sonar or testing explosives is low (less than one) in any year, but one auditory injury is predicted from both sources in the maximum year of impacts due to summing risk across seven years. Over the 7-year MMPA authorization period, NAEMO estimates a total of six AINJ exposures for Rice's whales: one from Navy testing with explosives; one from Navy training with sonar; and four from Navy testing with sonar (Navy 2024i). Given their restrictive core range and limited migratory behavior (compared to other large whales), we anticipated that all life stages of Rice's whales could be exposed to the effects of sonar and explosives resulting from AFTT activities.

Table 56. Estimated Acoustic and Explosive Effects to the Rice's Whale over a Maximum Year of Proposed Activities (Navy 2024a)

Source	Category	BEH	TTS	AINJ	INJ	MORT	
Explosive	Navy Training	0	(1)	-	-	-	
Explosive	Navy Testing	7	4	(1)	-	-	
Sonar	Navy Training	1	6	(1)	-	-	
Sonar	Navy Testing	79	204	1	-	-	
Sonar	USCG Training	(1)	-	-	-	-	
Maximum Annual Total		88	215	3	-	-	
Population Abundance Estimate		Annual Impacts per Individual		Annual Injurious Impacts per Individual			
118		2.59		0.03			
Percent of Total Impacts							
Gulf of America							
Season							
Winter		45%					
Spring		19%					
Summer		11%					
Fall		25%					
Activities with 5% or More of Total Impacts				Category	Percent of Total Impacts		
Unmanned Underwater Vehicle Testing				Navy Testing	68%		
Acoustic and Oceanographic Research (ONR)				Navy Testing	12%		
Mine Countermeasure Mission Package Testing				Navy Testing	10%		
Area Type	Area Name (Active Months)		BEH	TTS	AINJ	INJ	MORT
Draft BIA II	Expanded Range (All)		83	194	1	-	-
Draft BIA II	Northeastern Gulf of America (All)		79	181	0	-	-

BEH = Significant Behavioral Response, TTS = Temporary Threshold Shift, AINJ = Auditory Injury, INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. Asterisk (*) indicates no reliable abundance estimate is available. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Blue Whale

Estimated exposures resulting in adverse effects to blue whales from the use of sonar and explosives as part of the proposed action are shown in Table 57. Most predicted impacts are TTS resulting from sonar systems used in testing and training activities in the Mid-Atlantic and Southeast (Navy 2024a). The risk of auditory injury from testing sonar is low (less than one) in any year, but an auditory injury is shown in the maximum year of impacts due to summing risk across seven years. Over the 7-year MMPA authorization period, NAEMO estimates a total of two AINJ exposures for blue whales from Navy testing with sonar (Navy 2024i). Estimated impacts from explosives would be limited, and there are no estimated impacts from air guns. Although all life stages of blue whales could be impacted, we anticipate that most impacts would be to juveniles and adults, as we have no information indicating the action area includes breeding or calving grounds for this species.

Fin Whale

Estimated exposures resulting in adverse effects to fin whales from the use of sonar, air guns, and explosives as part of the proposed action are shown in Table 58. Most auditory impacts are attributable to low and mid- frequency sonar systems used in testing activities and anti-

submarine warfare sonar systems in the Northeast and VACAPES Range Complexes (Navy 2024a). Seasonally, the majority of impacts are expected in the spring and winter. Although all life stages of fin whales could be impacted, we anticipate that most impacts would be to juveniles and adults, as we have no information indicating the action area includes breeding or calving grounds for this species.

Table 57. Estimated Acoustic and Explosive Effects to Blue Whales over a Maximum Year of Proposed Activities (Navy 2024a)

Source	Category	BEH	TTS	AINJ	INJ	MORT
Explosive	Navy Training	(1)	(1)	-	-	-
Explosive	Navy Testing	(1)	1	-	-	-
Sonar	Navy Training	6	32	0	-	-
Sonar	Navy Testing	4	25	(1)	-	-
Sonar	USCG Training	0	-	-	-	-
Maximum Annual Total		12	59	1	-	-
Population Abundance Estimate		Annual Impacts per Individual		Annual Injurious Impacts per Individual		
402		0.18		0.00		
Percent of Total Impacts						
Season	Northeast	Mid-Atlantic	Southeast		High Seas	
Winter	6%	18%	10%		1%	
Spring	4%	13%	6%		1%	
Summer	3%	6%	6%		1%	
Fall	2%	11%	11%		1%	
Activities with 5% or More of Total Impacts			Category	Percent of Total Impacts		
Anti-Submarine Warfare Tracking Exercise - Ship			Navy Training	20%		
At-Sea Sonar Testing			Navy Testing	19%		
Acoustic and Oceanographic Research (ONR)			Navy Testing	12%		
Surface Ship Sonar Maintenance and Systems Checks			Navy Training	8%		
Small Coordinated ASW			Navy Training	8%		
Composite Training Unit Exercise			Navy Training	7%		

BEH = Significant Behavioral Response, TTS = Temporary Threshold Shift, AINJ = Auditory Injury, INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Table 58. Estimated Acoustic and Explosive Effects to Fin Whales over a Maximum Year of Proposed Activities (Navy 2024a)

Source	Category	BEH	TTS	AINJ	INJ	MORT	
Air gun	Navy Testing	(1)	-	-	-	-	
Explosive	Navy Training	30	8	0	-	-	
Explosive	Navy Testing	110	75	3	-	-	
Explosive	USCG Training	(1)	(1)	0	-	-	
Sonar	Navy Training	218	833	6	-	-	
Sonar	Navy Testing	328	1,010	12	-	-	
Sonar	USCG Training	(1)	-	-	-	-	
Maximum Annual Total		689	1,927	21	-	-	
Population Abundance Estimate		Annual Impacts per Individual		Annual Injurious Impacts per Individual			
6,802		0.39		0.00			
Percent of Total Impacts							
Season	Northeast	Mid-Atlantic		Southeast			
Winter	9%	22%		1%			
Spring	13%	24%		1%			
Summer	8%	8%		0%			
Fall	6%	8%		0%			
Activities with 5% or More of Total Impacts				Category	Percent of Total Impacts		
Acoustic and Oceanographic Research (ONR)				Navy Testing	18%		
At-Sea Sonar Testing				Navy Testing	15%		
Anti-Submarine Warfare Tracking Exercise - Ship				Navy Training	11%		
Surface Ship Sonar Maintenance and Systems Checks				Navy Training	7%		
Small Coordinated ASW				Navy Training	7%		
Mine Countermeasure and Neutralization Testing (NAVSEA)				Navy Testing	6%		
Area Type	Area Name (Active Months)		BEH	TTS	AINJ	INJ	MORT
Draft BIA II	East of Montauk Point (3,4,5,6,7,8,9,10)		5	0	-	-	-
Draft BIA II	Southern Gulf of ME (All)		16	36	0	-	-

BEH = Significant Behavioral Response, TTS = Temporary Threshold Shift, AINJ = Auditory Injury, INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Sei Whale

Estimated exposures resulting in adverse effects to sei whales from the use of sonar, air guns, and explosives as part of the proposed action are shown in Table 59. The majority of impacts are from Navy training and testing activities involving sonar, with limited impacts from explosives and none predicted from air guns. Impacts would be more likely in the spring while sei whales are on their feeding grounds in the northeast, shifting to the Mid-Atlantic and southeast as the species migrates south in the winter (Navy 2024a). Impacts are attributable to a variety of activities, with auditory injury attributable to anti-submarine warfare activities. Auditory impacts are also attributable to low and mid-frequency sonar systems during other testing activities, including those with higher duty cycles. Although all life stages of sei whales could be impacted, we anticipate that most impacts would be to juveniles and adults, as we have no information indicating the action area includes breeding or calving grounds for this species.

Table 59. Estimated Acoustic and Explosive Effects to Sei Whales over a Maximum Year of Proposed Activities (Navy 2024a)

Source	Category	BEH	TTS	AINJ	INJ	MORT	
Explosive	Navy Training	4	(1)	0	-	-	
Explosive	Navy Testing	6	3	0	-	-	
Explosive	USCG Training	(1)	0	-	-	-	
Sonar	Navy Training	38	313	3	-	-	
Sonar	Navy Testing	75	305	4	-	-	
Sonar	USCG Training	(1)	-	-	-	-	
Maximum Annual Total		125	622	7	-	-	
Population Abundance Estimate		Annual Impacts per Individual		Annual Injurious Impacts per Individual			
6,292		0.12		0.00			
Percent of Total Impacts							
Season	Northeast	Mid-Atlantic	Southeast	High Seas			
Winter	4%	13%	18%	4%			
Spring	27%	13%	0%	1%			
Summer	4%	0%	0%	0%			
Fall	3%	5%	7%	1%			
Activities with 5% or More of Total Impacts			Category	Percent of Total Impacts			
At-Sea Sonar Testing			Navy Testing	23%			
Anti-Submarine Warfare Tracking Exercise - Ship			Navy Training	19%			
Acoustic and Oceanographic Research (ONR)			Navy Testing	9%			
Composite Training Unit Exercise			Navy Training	5%			
Area Type	Area Name (Active Months)		BEH	TTS	AINJ	INJ	MORT
Draft BIA II	Gulf of ME (5,6,7,8,9,10,11)		18	57	0	-	-

BEH = Significant Behavioral Response, TTS = Temporary Threshold Shift, AINJ = Auditory Injury, INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Sperm Whale

Estimated exposures resulting in adverse effects to sperm whales from the use of sonar, air guns, and explosives as part of the proposed action are shown in Table 60 for the North Atlantic stock and Table 61 for the Gulf of Mexico stock. Most estimated impacts to the North Atlantic stock are from anti-submarine warfare activities densities in deep waters near and beyond the Atlantic continental shelf break, especially in the Mid-Atlantic, where higher densities of sperm whales occur. The risk of a auditory or non-auditory injury from training explosives and the risk of auditory injury from training sonar are low (less than one) in any year for this stock, but single instances of each are shown in the maximum year of impacts due to summing risk across seven years (Navy 2024a). Over the 7-year MMPA authorization period, NAEMO estimates a total of 25 AINJ exposures for sperm whales: six from Navy testing with explosives; three from Navy training with explosives; one from Navy training with sonar; and 15 from Navy testing with sonar (Navy 2024i).

Estimated impacts to the Gulf of Mexico sperm whale stock are due to a variety of military readiness activities across the Gulf of America to Key West including sonobuoy lot acceptance testing, UUV testing and acoustic and oceanographic research. Because fewer anti-submarine

warfare activities with hull-mounted sonar systems are used in this region, there are relatively fewer impacts to this stock compared to the North Atlantic stock. There are no auditory or non-auditory injuries predicted for this stock.

In general, sperm whale impacts due to explosives are limited, and there would be no impacts due to air guns. Although all life stages of sperm whales could be impacted, we anticipate that most impacts would be to juveniles and adults, as we have no information indicating the action area includes breeding or calving ground for this species.

Table 60. Estimated Acoustic and Explosive Effects to the North Atlantic Stock of Sperm Whales over a Maximum Year of Proposed Activities (Navy 2024a)

Source	Category	BEH	TTS	AINJ	INJ	MORT
Air gun	Navy Testing	0	-	-	-	-
Explosive	Navy Training	4	6	(1)	(1)	-
Explosive	Navy Testing	2	1	(1)	-	-
Explosive	USCG Training	(1)	0	-	-	-
Sonar	Navy Training	5,692	1,487	(1)	-	-
Sonar	Navy Testing	3,174	2,218	3	-	-
Sonar	USCG Training	5	-	-	-	-
Maximum Annual Total		8,878	3,712	6	1	-
Population Abundance Estimate		Annual Impacts per Individual		Annual Injurious Impacts per Individual		
5,895		2.14		0.00		
Percent of Total Impacts						
Season	Northeast	Mid-Atlantic	Southeast		High Seas	
Winter	3%	24%	1%		2%	
Spring	2%	21%	1%		2%	
Summer	3%	16%	1%		1%	
Fall	2%	19%	1%		2%	
Activities with 5% or More of Total Impacts				Category	Percent of Total Impacts	
Anti-Submarine Warfare Tracking Exercise - Ship				Navy Training	23%	
At-Sea Sonar Testing				Navy Testing	21%	
Surface Ship Sonar Maintenance and Systems Checks				Navy Training	11%	
Small Coordinated ASW				Navy Training	6%	
Acoustic and Oceanographic Research (ONR)				Navy Testing	5%	

BEH = Significant Behavioral Response, TTS = Temporary Threshold Shift, AINJ = Auditory Injury, INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Table 61. Estimated Acoustic and Explosive Effects to the Gulf of Mexico Stock of Sperm Whales over a Maximum Year of Proposed Activities (Navy 2024a)

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Explosive	Navy Training	(1)	(1)	0	-	-
Explosive	Navy Testing	(1)	(1)	0	0	0
Explosive	USCG Training	0	-	-	-	-
Sonar	Navy Training	32	4	-	-	-
Sonar	Navy Testing	214	21	-	-	-
Maximum Annual Total		248	27	0	0	0
Population Abundance Estimate		Annual Impacts per Individual		Annual Injurious Impacts per Individual		
1,614		0.17		0.00		
Percent of Total Impacts						
Season	Key West	Gulf of America				
Winter	10%	11%				
Spring	8%	11%				
Summer	10%	20%				
Fall	11%	18%				
Activities with 5% or More of Total Impacts				Category	Percent of Total Impacts	
Sonobuoy Lot Acceptance Test				Navy Testing	19%	
Unmanned Underwater Vehicle Testing				Navy Testing	16%	
Acoustic and Oceanographic Research (ONR)				Navy Testing	12%	
Torpedo (Non-Explosive) Testing				Navy Testing	10%	
Anti-Submarine Warfare Tracking Test (Fixed-Wing)				Navy Testing	10%	
Submarine Sea Trials - Weapons System Testing				Navy Testing	7%	
Airborne Mine Countermeasures - Mine Detection				Navy Training	7%	
Anti-Submarine Warfare Tracking Exercise - Ship				Navy Training	6%	

BEH = Significant Behavioral Response, TTS = Temporary Threshold Shift, AINJ = Auditory Injury, INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Response Analysis

Given the above estimated exposures of ESA-listed marine mammals to acoustic and explosives stressors associated with the proposed action, in this section we describe the range of responses to those exposures. This includes significant behavioral responses, sound-induced hearing loss (i.e., TTS and AINJ), non-auditory injury, as well as other possible responses (e.g., physiological stress) that marine mammals may exhibit when exposed to sound fields from these sources. Masking can also occur when the perception of a biologically-important sound is interfered with by a second sound (e.g., noise from Navy training and testing).

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sources, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging, there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007). Furthermore, many other factors besides the received level of sound may affect an animal's reaction such as the duration of the sound-

producing activity, the animal's physical condition, prior experience with the sound, activity at the time of exposure (e.g., feeding, traveling, resting), the context of the exposure (e.g., in a semi-enclosed bay vs open ocean), and proximity to the source of the sound. Studies on captive odontocetes suggest some species may learn to reduce their hearing sensitivity (presumably to protect their hearing) when warned of an impending intense sound exposure (Nachtigall and Supin 2013; Nachtigall et al. 2016; Finneran 2018). It is unknown if marine mammals in the wild would also suppress their hearing if they could anticipate an impending, intense sound, or during a prolonged exposure (even if unanticipated).

Our aim with this response analysis is to assess the potential responses that might reduce the overall fitness of individual ESA-listed marine mammals. Such responses would likely rise to the level of take under the ESA. Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. §1532(19)). NMFS's Policy Directive (NMFS 2023h) defines the term harass : *to create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering*. Harm is defined as an act that actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR §222.102).

Non-Auditory Injury

From our exposure analysis above, proposed AFTT activities involving in-water explosives will result in a small number (i.e., less than one per year) of non-auditory injuries to sperm whales. Non-auditory injuries are not anticipated to occur in any other ESA-listed marine mammal species due to the proposed action.

Explosive injury to marine mammals would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Corey et al. 1943; Richmond et al. 1973; General 1991). The near instantaneous high magnitude pressure change near an explosion can injure an animal where tissue material properties significantly differ from the surrounding environment, such as around air-filled cavities such as in the lungs or gastrointestinal tract. Large pressure changes at tissue-air interfaces in the lungs and gastrointestinal tract may cause tissue rupture, resulting in a range of injuries depending on degree of exposure. The lungs are typically the first site to show any damage, while the solid organs (e.g., liver, spleen, and kidney) are more resistant to blast injury (Ward and W. 1943). Recoverable injuries would include slight lung injury, such as capillary interstitial bleeding, and contusions to the gastrointestinal tract. More severe injuries, such as tissue lacerations, major hemorrhage, organ rupture, or air in the chest cavity (pneumothorax), would significantly reduce fitness and likely cause death in the wild. Rupture of the lung may

also introduce air into the vascular system, producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to critical organs.

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. Because gas-containing organs are more vulnerable to primary blast injury, adaptations for diving that allow for collapse of lung tissues with depth may make animals less vulnerable to lung injury with depth.

Relatively little is known about auditory system trauma (i.e., tissue damage) in marine mammals resulting from explosive exposure, although it is assumed that auditory structures would be vulnerable to blast injuries. Here, we consider primary blast injury to auditory tissues, which is distinct from TTS or AINJ discussed below. Auditory trauma was found in two humpback whales that died following the detonation of a 5,000 kilogram explosive used off Newfoundland during demolition of an offshore oil rig platform (Ketten et al. 1993), but the proximity of the whales to the detonation was unknown. Eardrum rupture was examined in submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973). However, results may not be applicable to the anatomical adaptations for underwater hearing in marine mammals.

For the purposes of this analysis, we assume that sperm whales experiencing a non-auditory injury would be temporarily impaired as a result, but will ultimately recover. While the animal is recovering from its injury, though there is some uncertainty, we assume the animal's ability to conduct important life functions (e.g., breeding, feeding) would be diminished, but that the animal would survive. We do not have information available to determine how long an injured sperm whale would remain impaired. For a slight lung injury (e.g., pulmonary contusion), which defines the threshold for onset of non-auditory injury, it is reasonable to assume the whale would recover within several months. A more severe injury could take longer until full recovery, which could result in a decrease in the animal's reproductive potential, particularly if it occurs to a mature female. However, given their long life spans, it is unlikely that a single injury would result in a significant impact on the life-time reproductive potential of an individual sperm whale.

Hearing Loss and Auditory Injury

Numerous studies have directly examined noise-induced hearing loss in marine mammals. The major findings from these studies are summarized in the AFTT BA (Section 4.4.2.1.1.3, Table 4.4-3, pp. 4-430 to 4-431), which we incorporate here by reference.

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received level, temporal pattern, and duration. Hearing loss is typically quantified in terms of threshold shift — the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of threshold shift measured usually decreases with increasing recovery time — the amount of time that has elapsed since a noise exposure. If the threshold shift eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is considered temporary or TTS. If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is determined to be permanent or PTS. The frequencies affected by hearing loss will vary depending on the frequency of the noise, with frequencies at and above the noise frequency most strongly affected (i.e., higher amount of threshold shift). The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies.

Studies have revealed that intense noise exposures may also cause auditory system injury that does not result in PTS (i.e., hearing thresholds return to normal after the exposure, but there is injury nonetheless). Kujawa and Liberman (2009) found that noise exposures sufficient to produce a TTS of 40 dB, measured 24 hours post-exposure, resulted in acute loss of nerve terminals and delayed degeneration of the cochlear nerve in mice. Lin et al. (2011) found a similar result in guinea pigs with a TTS in auditory-evoked potential up to approximately 50 dB, measured 24 hours post-exposure resulting in neural degeneration. These studies demonstrate that PTS should not be used as the sole indicator of auditory injury because exposures producing high levels of TTS (40 to 50 dB measured 24 hours after exposure) — but no PTS — may result in auditory injury or impairment.

Also important to consider is the potential for repeat instances of TTS due to exposure to acoustic stressors. In some exposure scenarios, it is possible that a particular animal will be exposed to sonar resulting in TTS and then, prior to being fully recovered, will be exposed again at a level resulting in TTS. Experimental studies have not explored such scenarios, so there is uncertainty as to how long recovery would take in these particular cases. It is possible that repeat instances of TTS could result in PTS. This has been shown in terrestrial animals (Kujawa and Liberman 2009; Lin et al. 2011), and in one case, marine mammals as well (Kastak et al. 2008).

Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to several days to fully recover, depending on the magnitude of the initial threshold shift. Small amounts of TTS (a few dB) typically begin to recover immediately after the sound exposure and may fully recover in minutes, while larger amounts of TTS take longer to recover. Studies have also found substantial individual variation both in the amount of TTS produced by similar SELs (Kastelein et al. 2012; Popov et al. 2013), and in recovery from similar TTS (Finneran 2015; Kastelein et al. 2019). Compared to TTS, PTS (or AINJ) has more

potential to affect aspects of an animal's life functions, including those that do not overlap in time and space with the proposed action.

Whether or not a hearing threshold shift will impact an individual animal's fitness depends on the duration, frequency, and magnitude of the shift. The Action Proponents use sonars operating at a wide range of frequencies (i.e., from low frequency sources to extremely high frequency sources). Marine mammals that experience PTS or TTS from sonar sounds are likely to have reduced ability to detect biologically important sounds around the frequency band of the sonar until their hearing recovers. Some instances of hearing threshold shift are likely to occur at frequencies utilized by animals for acoustic cues. For example, during the period that a marine mammal has hearing loss, social calls from conspecifics could be more difficult to detect or interpret if they fell in the octave band of the sonar frequency. The ability to detect anthropogenic sounds may be important to provide information on the location and direction of human activities, and may provide a warning regarding nearby activities (e.g., vessels) that may be hazardous. The ability to detect conspecifics is also important for mating and mother-calf communication. Depending on the severity and frequency range affected, PTS and TTS may also impact foraging success for sperm whales and other echolocating odontocetes that rely on sound to find prey. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether hearing loss would affect a mysticete's ability to locate prey or rate of feeding.

Since marine mammals depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators), fitness consequences could occur to individual animals from hearing threshold shifts that last for a long time, occur at a frequency utilized by the animal for acoustic cues, and are of a profound magnitude. A hearing threshold shift of limited duration, occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues, would likely have little to no effect on an animal's fitness. Because narrow-band active sonar is typically transmitted at a specified frequency, animals experiencing TTS or AINJ from narrow-band sonar would likely only experience threshold shifts around that particular frequency. By contrast, for animals experiencing TTS or AINJ from broadband sonar sources or explosives, which are considered broadband, a greater frequency band would likely be affected. Since a greater frequency band could be affected due to broadband sound sources, there is an increased chance that the resulting hearing impairment will affect frequencies utilized by animals for acoustic cues.

Based on the best available information, we expect instances of TTS from AFTT sonar and explosives to be short-term and of relatively low severity because of animal avoidance and the transient nature of most sonar and explosive sources. This conclusion is supported by studies indicating that even following relatively prolonged periods of sound exposure resulting in TTS, recovery occurs quickly (Finneran 2015). Additionally, we do not anticipate that marine mammals will experience long duration or repeat exposures within a short period of time due to the species wide ranging life histories and the fact that long duration (i.e., more than one day)

AFTT activities also occur over large geographic areas (i.e., both the whales and the activity are moving within the action area, most likely not in the same direction). This decreases the likelihood that animals and AFTT activities will co-occur for extended periods of time or repetitively over the duration of an activity. From our exposure analysis (Section 6.1.1.5), the average number of annual TTS impacts per individual was less than one for all large whale species, except Rice's whales for which the average was about two per individual. Although some individual whales may experience TTS more often than the average, this still suggests that the maximum number of TTS exposures for any given individual will be relatively small (i.e., likely less than five per year). Any adverse effects resulting from TTS are expected to be relatively minor and short-term. For these reasons, we do not anticipate that instances of TTS from AFTT activities will result in long-term fitness consequences affecting the reproduction or survival of ESA-listed whales.

Unlike TTS, AINJ could be permanent (e.g., PTS), meaning the effects of the injury last well beyond the duration of the proposed action and outside of the action area as animals migrate. While hearing loss in whales resulting from exposure to PTS-causing sound levels is not expected to deafen the animals, we expect it would have some effect on the hearing ability of the whales in the frequencies of the sound that caused the damage. For the purposes of this assessment, we assume that the frequencies affected overlap with those utilized by animals for acoustic cues. Therefore, PTS may interfere with a whale's ability to hear sounds produced by ships, construction activities, seismic surveys, or communication signals of conspecifics. The ability to detect anthropogenic sounds may be important to provide information on the location and direction of human activities, and may provide a warning regarding nearby activities that may be hazardous. The ability to detect conspecifics is important for socialization, mating and mother-calf communication. Depending on the severity, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although the available information does not allow us to quantify the proportion of AINJ that will result in mild, moderate or high severity PTS, nor to evaluate how such threshold shifts directly relate to individual whale fitness.

We anticipate that a large majority of PTS exposures resulting from the proposed action would be of mild severity due to conservative assumptions incorporated into the NAEMO modeling of quantitative impacts (Navy 2024h) and the proposed mitigation measures described in Section 2.3.2. Individual whales experiencing a minor degree of PTS could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and should still be able to detect threats with enough time to avoid injury. Similarly, while sperm whales could also be less efficient at finding prey using echolocation, we expect sperm whales with a minor degree of PTS will still be able to forage successfully. Our conclusion that whales with mild severity PTS will still be able to perform these important life functions assumes that these individuals are reasonably healthy at the time of exposure, and are not compromised or impacted by other stressors such as entanglement, vessel strike, or nutritional deficiency.

Although we anticipate that a large majority of PTS exposures resulting from AFTT activities will be of mild severity, it remains possible that some exposures could result in more severe incidents of PTS, with greater fitness consequences for those individual whales exposed. As discussed above, higher severity instances of PTS that can lead to fitness consequences are more likely to occur from exposure to broadband sound sources (e.g., explosives), since there is an increased chance that the resulting hearing impairment will affect frequencies utilized by animals for acoustic cues. From our exposure analysis above, fin whales are expected to be exposed to 21 AINJ exposures annually from all sources during a maximum year of AFTT activity, with three of these AINJ exposures coming from explosive sound sources. None of the other large whale species are expected to be exposed to more than seven AINJ annually in a maximum year. NAEMO estimates 17 fin whale and nine sperm whale AINJ exposures from explosives every seven years. For the other four large whale species (North Atlantic right whale, Rice's whale, sei whale, and blue whale) the estimated number of AINJ (including PTS) exposures from explosives every seven years is one or less. Therefore, while moderate to high severity instances of PTS are expected to be rare, in general, the likelihood of this occurring is greater for fin and sperm whales given the relatively large number of AINJ impacts (and specifically impacts from explosives) estimated for these species. For the other large whale species, all instances of PTS resulting from the proposed action are anticipated to be of mild severity, given the relatively small number of estimated AINJ impacts to these species (and specifically impacts from explosives), the conservative assumptions incorporated into the NAEMO modeling of quantitative impacts (Navy 2024h), and the proposed mitigation measures.

Masking

Masking occurs when one sound, distinguished as the “noise,” interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in dB an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al. 2015). Masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, changing frequency, or cessation of vocalization) and behavioral changes (e.g., cessation of foraging, leaving an area) on the part of both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al. 2015).

Masking of mysticete calls could occur due to the overlap between their low-frequency vocalizations and the dominant frequencies of impulsive sources (Castellote et al. 2012). For example, blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio and Clark 2010), indicative of a possible compensatory response to masking effects of the increased noise level. However, mysticetes that call at higher rates are less likely to be masked by impulsive noise with lower duty cycles (Clark et al. 2009c) because of the decreased likelihood that the noise would overlap with the calls, and because of dip listening. Field

observations of masking effects such as vocal modifications are difficult to interpret because when recordings indicate that call rates decline, this could be caused by (1) animals calling less frequently (actual noise-induced vocal modifications), (2) the calls being masked from the recording hydrophone due to the noise (e.g., animals are not calling less frequently but are being detected less frequently), or (3) the animals moving away from the noise, or any combination of these causes (Blackwell et al. 2013; Cerchio et al. 2014).

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes may result from a need to compete with an increase in background noise and include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkiss and Parks 2013). Vocal changes can be temporary or permanent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen and Parks 2016). This shift in frequency was modeled, and it was found that it led to increased detection ranges between right whales. The frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than 3 km to over 9 km (Tennessen and Parks 2016). North Atlantic right whale source levels, which range from 137 to 192 dB, are low compared to some other baleen whales, which may put this species at greater risk of communication masking compared to other species (Clark et al. 2009b; Hatch et al. 2012).

In some cases, vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al. 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may also move beyond vocal modifications (Dunlop et al. 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a different location to improve binaural cues (time or intensity differences between the ears due to a sound source's location relative to the animal's head), or going still to reduce noise associated with hydrodynamic flow. The structure of some noises (e.g., amplitude modulation) may also provide some release from masking through comodulation masking release (the difference in masking when a noise is broadband versus having the same bandwidth as the signal; Branstetter and Finneran 2008). Signal characteristics (e.g., whether the signal has harmonics or is frequency modulated) may further enhance the detectability of a signal in noise (Cunningham et al. 2014).

Masking could occur as a result of sonar and other transducers. Low-frequency active sonar used for the proposed action could result in masking if there is overlap between the sound source frequencies and mysticete vocalizations (e.g., humpback whales). In the presence of low-

frequency active sonar, humpback whales have been observed to increase the length of their songs (Miller et al. 2000; Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar.

The duty cycle of the sound source can also influence the degree of masking. Duty cycle refers to the ratio of time a sonar system is actively transmitting sound waves to the total time, often expressed as a percentage. For active sonar sources, duty cycle is a measure of the length of the gap between sonar pulses. For military sonar systems with low duty cycles, relatively short duration, and narrow bandwidth that do not overlap with vocalizations for most marine mammal species, masking would be limited as compared to continuous sound sources. However, newer high duty cycle or continuous active sonar systems have more potential to mask vocalizations, particularly for mid-frequency cetaceans (e.g., ESA-listed sperm whales) given the overlap in vocalization frequency with these sonar systems. These sonar systems transmit more frequently (greater than 80% duty cycle) than traditional sonars, but at a substantially lower source level. While the lower source levels of these systems limits the range of impact compared to more traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. von Benda-Beckmann et al. (2021) modeled the effect of pulsed and continuous 1 to 2 kHz active sonar on sperm whale echolocation clicks, and found that the presence of upper harmonics in the sonar signal increased masking of clicks produced in the search phase of foraging compared to buzz clicks produced during prey capture. Different levels of sonar caused intermittent to continuous masking (120 to 160 dB re 1 μ Pa², respectively), but varied based on click level, whale orientation, and prey target strength. Continuous active sonar resulted in a greater percentage of time that echolocation clicks were masked compared to pulsed active sonar.

Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, acoustically mediated cooperative behaviors (Sørensen et al. 2023) such as foraging and mating, and can also trigger changes to vocalization amplitude and frequency (Brumm and Slabbekoorn 2005; Hotchkiss and Parks 2013). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al. 2004), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm and Slabbekoorn 2005), a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al. 2003), and a potential decrease in survivorship if predator vocalizations (e.g., killer whales) are masked (Brumm and Slabbekoorn 2005).

The proposed action includes training and testing activities involving mid-frequency continuous active sonar. Navy sonar bin MF1C (previously referred to as MF11 for AFTT Phase III) includes hull-mounted surface ship sonars with active duty cycle greater than 80%. AFTT proposed activity levels for this continuous source of active sonar are shown above in Section 2.4.1, Table 28. Mid-frequency continuous active sonar (MF1C) is primarily used during AFTT ASW activities. From our acoustics exposure analysis above, based on the proportion of acoustic

impacts from ASW activities, the ESA-listed marine mammals that are most likely to be exposed to this continuous sonar source are as follows: blue whales (20% ASW Tracking Exercises; 8% Small Coordinated ASW Exercises); fin whales (11% ASW Tracking Exercises; 7% Small Coordinated ASW Exercises); sei whales (19% ASW Tracking Exercises); sperm whales – North Atlantic stock (23% ASW Tracking Exercises; 6% Small Coordinated ASW Exercises); and sperm whales – Gulf of Mexico stock (6% ASW Tracking Exercises; 10% ASW Tracking Test). Although the NAEMO analysis did not provide the estimated number of impacts by sonar source, the Navy has indicated that the use of continuous active sonar (MF1C) in hours is about a third of pulsed active sonar (MF1).

Results of the new studies were variable in terms of finding differences between continuous and non-continuous active sonar. von Benda-Beckmann et al. (2021) provides initial support for the hypothesis that continuous active sonars have more potential to mask vocalizations, particularly for sperm whales, as compared to pulsed sources. However, at this time, there is not sufficient information regarding the behavioral effects resulting from continuous active sonar to assess the impact of this stressor on marine mammals. Based on our exposure analysis, it is likely that blue, fin, sei, and sperm whales will be exposed to continuous active sonar sources at levels resulting in masking effects that are longer lasting compared to pulsed active sonar (MF1). While longer-term masking could lead to behavioral disruptions affecting communication and social interactions, based on our exposure analysis we expect, at most, only a few instances of masking from continuous active sonar per individual whale annually.

Unlike continuous or high-duty cycle systems, impulsive sound sources, including explosions, are intense and typically short in duration. Since impulsive noise is intermittent, the length of the gap between sounds (duty-cycle) and the received level are pertinent when considering the potential for masking. Impulsive sounds with lower duty cycles or lower received levels are less likely to result in masking than higher duty cycles or received levels. There are no direct observations of masking in marine mammals due to exposure to explosive sources. Potential masking from explosive sounds or weapon noise is likely similar to masking studied for other impulsive sounds, such as air guns or pile-driving.

Behavioral and Physiological Stress Responses

Acoustic stimuli in the marine environment can cause a behavioral response in marine mammals and can also influence how or if a marine mammal responds to a sound such as the presence of predators, prey, or conspecifics. The response of a marine mammal to anthropogenic sound depends on the frequency, duration, temporal pattern and amplitude of the sound, as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al. 2012). The distance from the sound source and whether it is approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al. 2003).

Behavioral Responses to Sonar and Other Transducers

Sonar and other transducers can range in frequency (from less than 1 kHz to over 200 kHz) and duty cycles (from one ping per minute to an almost continuous sound). These acoustic sources can also be stationary or operated from a moving platform, and there can be one or multiple sources present at a time. This variability in parameters associated with sonar and other transducers makes the estimation of behavioral responses to these sources difficult, with observed responses ranging from no apparent change in behavior to more severe responses that could lead to some costs to the animal. Responses may also occur in the presence of different contextual factors regardless of received level, including the proximity and number of vessels, the behavioral state and prior experience of an individual, and even characteristics of the signal itself or the propagation of the signal through the environment.

Southall et al. (2016) reviewed the range of experimental field studies that have been conducted to measure behavioral responses of cetaceans to sonar. While, in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007; Southall et al. 2016). Common responses to sonar during controlled exposure experiments include avoidance of the area of sonar exposure, cessation or modification of vocal behavior, and cessation of foraging (Southall et al. 2007; Southall et al. 2016). More minor reactions have also been observed including alerting to the sound source and startle responses. Based on their review, Southall et al. (2016) found that many, but not all responses of cetaceans to sonar reported in the literature have been relatively mild and/or brief.

It should be noted that the responses of animals to real world Navy sonar could vary from the small scale, short-term controlled exposure experiments reviewed by Southall et al. (2016). Most of the studies reviewed by Southall et al. (2016) involved a single platform transmitting sonar or another sound source for a short period of time. This is in contrast to what would be expected during some military activities (e.g., MTEs) involving sonar where multiple vessels are operating concurrently in close proximity, during an exercise that lasts for an extended period of time (i.e., multiple days to weeks). The response of an animal to an initial exposure during such an event may be different than what could be expected if an animal is exposed multiple times or for a long period of time during an event. Additionally, while the experimental studies can implement controls for some variables (e.g., the distance and movement of the source), they also introduce additional variables that do not normally occur in a real training or testing activity, including the tagging of whales, intentionally following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation. In addition, Forney et al. (2017) noted that species that respond to noise from military sonars by avoiding an area are unlikely to be observed in these studies based on traditional methods (e.g., Lookouts or passive acoustic monitoring) because animals often react at distances far greater than the detection range of these methods.

Passive acoustic monitoring and visual observational behavioral response studies have also been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Mccarthy et al. 2011; Tyack et al. 2011; Moretti et al. 2014; Deakos and Richlen 2015; Martin et al. 2015; Mobley and Deakos 2015; Henderson et al. 2016; Manzano-Roth et al. 2016). However, passive acoustic studies are limited to observations of vocally-active marine mammals and visual studies are limited to what can be observed at the surface.

The responses of large whales to sonar and other duty-cycled tonal sounds are highly dependent upon the characteristics of the signal, the behavioral state of the animal, the particular sensitivity and previous experience of an individual, and other contextual factors including distance of the source, movement of the source, and the physical presence of vessels in addition to the sonar (Goldbogen et al. 2013; Harris et al. 2015; Martin et al. 2015; Sivle et al. 2015). Behavioral response studies have been conducted over a variety of contextual and behavioral states, helping to identify which contextual factors may lead to a response beyond just the received level of the sound. Observed reactions during behavioral response studies have not been consistent across individuals based on received sound levels alone, and likely were the result of complex interactions between these contextual factors.

Surface feeding blue whales did not show a change in behavior in response to mid-frequency simulated and real sonar sources with received levels between 90 and 179 dB re 1 μ Pa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior (Goldbogen et al. 2013; DeRuiter et al. 2017). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. Even when responses did occur, the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al. 2013).

A behavioral response study by Harris et al. (2019) looked at the lunge feeding rates of blue, fin, and humpback whales exposed to simulated naval sonar. Results showed that while blue and fin whale lunge rates remained similar to baseline regardless of exposure levels, humpback whales – which were exposed to the highest sonar sound levels – showed a greater degree of feeding disruption during and up to 15 minutes after sonar exposure. In a Norwegian behavioral response study, humpback whales responded more severely to killer whale vocalization playbacks than they did to the sonar playbacks, and may have been habituated slightly between the first and second sonar exposures (Sivle et al. 2015). Several humpback whales have been observed during aerial or visual surveys during Navy training events involving sonar (Sivle et al. 2016; Wensveen et al. 2017; Harris et al. 2019; Henderson et al. 2019). No avoidance or other behavioral responses were ever noted, even when the whales were observed within 5 km of a vessel with active (or possibly active) sonar and maximum received levels were estimated to be between 135 and 161 dB re 1 μ Pa (e.g., Smultea et al. 2009; Mobley 2011; Mobley and Pacini 2012). Studies from 1997 to 1998 conducted under the Navy's Low-Frequency Sound Scientific Research

Program found only short-term responses to LF sound by some fin and humpback whales, including changes in vocal activity and avoidance of the source vessel, while other fin, humpback, and blue whales did not respond at all.

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low-frequency calls usually associated with feeding behavior, beginning at received levels of 110 to 120 dB re 1 μ Pa (Melcon et al. 2012). However, they were unable to determine if suppression of calls reflected a change in their feeding performance or abandonment of foraging behavior.

Harris et al. (2019) used data from passive acoustic monitoring of Navy training ranges to test minke whale (another large, baleen whale in the low-frequency hearing group) responsiveness to naval sonar on the Navy's Pacific Missile Range Facility (PMRF) located off Kauai, Hawaii. They found that the distribution of calling whales changed in both years surveyed in the vicinity of the center of ship activity during naval warfare training activities, as compared to before such activities started. The avoidance behavior, as evidenced by the redistribution of calls, extended for approximately five days after the end of the training activity in both years. As the data are from passive acoustic monitoring, it is unknown whether this change in the probability of acoustic presence across the range is a result of whales moving away from the range or ceasing calling, or perhaps a combination of both. Henderson et al. (2019) studied humpback whale behavior in response to mid-frequency active sonar on the PMRF. While some behavioral response may have occurred in individuals exposed to mid-frequency active sonar, the authors noted that this response was limited, with the whales focused on breeding behavior. Durbach et al. (2021) analyzed acoustic tracks from minke whales detected on the PMRF three years before, during, and after major Navy training exercises. Results of this study showed that minke whales moved faster and movements were more directed during periods of active sonar. Minke whales also avoided the locations of the ships producing the sonar, and were more likely to cease calling during sonar.

Southall et al. (2019a) measured the degree of behavioral responses in blue whales to controlled exposure to mid-frequency military sonar off the southern California coast. More than 50% of blue whales in deep-feeding states responded to exposure experiments, whereas no changes in behavior were identified in shallow-feeding blue whales. Responses were generally brief, of low to moderate severity, and highly dependent on exposure context such as behavioral state, source-to-whale horizontal range and prey availability (Southall et al. 2019a). Using a similar experimental design, Southall et al. (2023) studied the behavioral responses of fin whales to military sonar and other stimuli. Behavioral changes were detected in 5 of 15 whales during controlled exposure experiments using mid-frequency active sonar or pseudo-random noise of similar frequency, duration and source and received level. No changes were detected during six control (no noise) sequences. Overall responses were more limited in occurrence, severity and duration than in blue whales and were less dependent upon contextual aspects of exposure and more contingent upon exposure received level (Southall et al. 2023). Results from Stanistreet et

al. (2022) suggest that beaked and sperm whales ceased foraging in the vicinity of a multinational naval exercise conducted off eastern Canada.

A growing number of behavioral response studies have been conducted on odontocete responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge and Durban 2009; Claridge et al. 2009; Moretti et al. 2009; McCarthy et al. 2011; Southall et al. 2012; Southall et al. 2013; Southall et al. 2014; Henderson et al. 2015; Wensveen et al. 2019; Isojunno et al. 2020). While these studies have focused primarily on non-ESA-listed beaked whales (or other smaller species), results suggest that sperm whales are not as sensitive to anthropogenic sound sources as these smaller odontocetes (Southall et al. 2009). However, in response to seismic surveys and naval sonar, sperm whales have demonstrated avoidance, changes in locomotion/orientation, changes in dive profiles, cessation of foraging, cessation of resting, and changes in vocal behavior (Miller et al. 2009; Miller et al. 2012; Sivle et al. 2012; Isojunno et al. 2016). Sperm whales may be more sensitive to larger amounts of cumulative sound energy they receive, rather than higher sound amplitudes during sonar exercises. Research on sperm whales in the Caribbean in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins et al. 1985). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general. Sperm whales in and around the Norwegian Sea were found to halt foraging behavior for longer periods of time following exposure to continuous sonar than they were following exposure to pulsed sonar of similar amplitudes, although these behavioral changes became more pronounced with increasing pulsed sonar amplitudes (Isojunno et al. 2020).

Behavioral Responses to In-Water Explosives and Air Guns

As shown in our exposure analysis above, NAEMO predicts significant behavioral responses from Navy explosives used in AFTT for all six marine mammal species considered in this opinion. Significant behavioral responses from Navy air guns are only predicted for fin whales, and at a very low level of occurrence (i.e., less than one exposure per year).

Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. At long distances the rise time increases as the signal duration lengthens (similar to a “ringing” sound), making the impulsive signal more similar to a non-impulsive signal.

Data on behavioral responses to impulsive sound sources are limited across all cetacean groups, with only a few studies available for mysticetes and odontocetes. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-airgun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by cetaceans, it is likely

that these responses represent a worst-case scenario as compared to responses to Navy impulsive sources such as explosives. Navy explosive activities typically consist of a single or multiple explosions occurring over a short period of time in a relatively small area; whereas seismic surveys input impulsive sound from airguns into the water column over a long period of time and over a large area (e.g., following a transect). The NAEMO quantitative effects analysis approach assumes that significant behavioral responses to solitary explosions would not occur due to the short duration of acoustic exposure from such explosions. The mitigation measures that would be implemented (such as exclusion zones) may further reduce the potential for significant behavioral responses to occur from exposure to solitary explosions.

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, attraction to the source, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Richardson et al. 1985; McCauley et al. 2000b; Gordon et al. 2003; Southall et al. 2007). As was discussed for responses to sonar, the behavioral state of the whale seems to be an integral part of whether or not the animal responds and how they respond to impulsive sources, as does the location and movement of the sound source, more than the received level of the sound. Depending on numerous factors (e.g., proximity, attentional focus, charge weight of blast, and experience of the animal) the behavioral responses of individuals may vary, and we would assume some animals would exhibit more of a reaction than others.

Migratory behavior seems to lead to a higher likelihood of response, with some large whale species demonstrating more sensitivity than others. For example, migrating gray whales showed avoidance responses to seismic vessels at received levels between 164 and 190 dB re 1 μ Pa (Malme et al. 1986; Malme et al. 1988). Similarly, migrating humpback whales in Australia showed avoidance behavior at ranges between 3 to 8 km from a seismic array during observational studies and controlled exposure experiments (McCauley et al. 1998; Dunlop et al. 2017), decreased their dive times, and reduced their swimming speeds in another study (Dunlop 2016). When comparing received levels and behavioral responses when using ramp-up versus a constant noise level of airguns, humpback whales did not change their dive behavior but did deviate from their predicted heading and decreased their swim speeds (Dunlop 2016). In addition, the whales demonstrated more course deviation during the constant source trials but reduced travel speeds more in the ramp-up trials. In either case, there was no dose-response relationship with the received level of the airgun noise, and similar responses were observed in control trials with vessel movement but no airguns, so some of the response was likely due to the presence of the vessel and not the received level of the airguns.

When looking at the relationships between proximity, received level, and behavioral response, Dunlop et al. (2017) used responses to two different airguns and found responses occurred more towards the smaller, closer source than to the larger source at the same received level, demonstrating the importance of proximity. Responses were found to be more likely when the source was within 3 km or above 140 dB re 1 μ Pa, although responses were variable and some animals did not respond at those values while others responded below them. In addition,

responses were generally small, with course deviations of only around 500 m, and short term (Dunlop et al. 2017). McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the seismic vessel (estimated received level 143 dB re 1 μ Pa peak-to-peak).

Vocal responses to seismic surveys have been observed in a number of baleen whale species, including a cessation of calling, a shift in frequency, increases in amplitude or call rate, or a combination of these strategies. Blue whale feeding/social calls were found to increase when seismic exploration was underway, with seismic pulses from a sparker at average received peak-to-peak measurements of 131 dB re 1 μ Pa²s (Di Lorio and Clark 2010), a potentially compensatory response to increased noise level. Responses by fin whales to a 10-day seismic survey in the Mediterranean Sea included possible decreased 20-Hz call production and movement of animals from the area based on lower received levels and changes in bearings (Castellote et al. 2012). However, similarly distant seismic surveys elicited no apparent vocal response from fin whales in the Mid-Atlantic Ocean; instead, Nieuwkirk et al. (2012) hypothesized that 20-Hz calls may have been masked from the receiver by distant seismic noise. Models of humpback whale song off Angola showed significant seasonal and diel variation, but also showed a decrease in the number of singers with increasing received levels of airgun pulses (Cerchio et al. 2014). Bowhead whale calling rates decreased significantly at sites near seismic surveys (41 to 45 km) where received levels were between 116 to 129 dB re 1 μ Pa, and did not decrease at sites further from the seismic surveys (greater than 104 km) where received levels were 99-108 dB re 1 μ Pa (Blackwell et al. 2013). In fact, bowhead whale calling rates increased at the lower received levels, began decreasing at around 127 dB re 1 μ Pa²s cumulative SEL, and ceased altogether at received levels over 170 dB re 1 μ Pa²s cumulative SEL (Blackwell et al. 2015). In other studies, noise from seismic surveys or explosions was not found to result in any behavioral response from mysticetes (Gailey et al. 2007; Yazvenko et al. 2007; Vilela et al. 2016).

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of America exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 NM away from the whales, and received levels were as high as 162 dB SPL re 1 μ Pa (Madsen et al. 2006). The whales showed no horizontal avoidance; however one whale rested at the water's surface for an extended period of time until airguns ceased firing (Miller et al. 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al. 2009). Similarly, Weir (2008) observed that seismic airgun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period, nor were avoidance behaviors to airgun impulsive sounds observed.

Physiological Stress Responses

Marine mammals naturally experience stress within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to disease and naturally occurring

toxins, lack of prey availability, and interactions with predators all contribute to the stress a marine mammal experiences (Atkinson et al. 2015). Breeding cycles, periods of fasting, and social interactions with conspecifics are also stressors, although they are natural components of an animal's life history. Anthropogenic activities, including acoustic and explosive sound sources, have the potential to provide additional physiological stress beyond those that occur naturally (Rolland et al. 2012; Fair et al. 2014; Meissner et al. 2015).

The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor (Moberg 2000). 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). The generalized stress response is classically characterized by the release of cortisol, a hormone that has many functions, including elevation of blood sugar, suppression of the immune system, and alteration of the biochemical pathways that affect fat, protein, and carbohydrate metabolism. It is now known that the endocrine response (glandular secretions of hormones into the blood) to a stressor can extend to other hormones. For instance, thyroid hormones can also vary under the influence of certain stressors, particularly food deprivation. These types of responses typically occur on the order of minutes to days. The "fight or flight" response, an acute stress response, is characterized by the very rapid release of hormones that stimulate glucose release, increase heart rate, and increase oxygen consumption.

Factors potentially affecting an animal's response to a stressor include the animal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether they are naïve or experienced with the sound (e.g., prior experience with a stressor may result in a reduced response due to habituation; St Aubin and Dierauf 2001; Finneran and Branstetter 2013). Because there are many unknowns regarding the occurrence of acoustically-induced stress responses in marine mammals, it is a reasonable assumption that any hearing loss, injury, or significant behavioral response is also associated with a stress response.

What is known about the function of the various stress hormones is based largely upon observations of the stress response in terrestrial mammals. However, the endocrine response of marine mammals to stress may not be the same as that of terrestrial mammals because of the selective pressures marine mammals faced during their evolution in an ocean environment (Atkinson et al. 2015). Relatively little information exists on the linkage between anthropogenic sound exposure and stress in large whales, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic).

Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly reduced in the region where fecal collections were made, and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al. 2012). Rolland et al. (2017) studied glucocorticoid hormones in North Atlantic right whales, evaluating and comparing healthy

whales with whales that were chronically entangled in fishing gear. The authors found that stress hormones in the entangled whales were elevated compared to those of healthy whales. The authors also cited several studies to conclude that stress responses over a short period of time (i.e., hours/days) can be beneficial and life-saving. However, chronic elevations of glucocorticoids (i.e., weeks/months) may result in decreased growth, depressed immune system function, and suppression of reproduction (e.g., Sapolsky et al. 2000; Romero and Wikelski 2001). Yang et al. (2021) measured cortisol concentrations in blood samples of two captive bottlenose dolphins and found significantly higher levels after exposure to high sound level (140 dB re 1 μ Pa) impulsive noise playbacks, compared to control and low sound levels (0 and 120 dB re 1 μ Pa, respectively). Results suggest that repeated exposures or sustained stress response to impulsive sounds reduce an individual's fitness.

Summary of Behavioral and Physiological Responses

In general, large whale behavioral responses to sonar appear to be fairly low to moderate severity across all received levels, with very few strong responses reported. Large whale responses also seem to be highly mediated by behavioral state, with no responses occurring in some behavioral states, and contextual factors and signal characteristics having more impact than received level alone. While some responses such as cessation of foraging or changes in dive behavior could carry short-term impacts, in all cases behavior returned to normal after the cessation of sound exposure. There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007). As noted in Southall et al. (2007), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours or recur on subsequent days. Other studies support the conclusion that behavioral responses to infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget and that long duration and repetitive disruptions would be necessary to result in consequential impacts to an animal (Southall et al. 2007; New et al. 2014; King et al. 2015; Villegas-Amtmann et al. 2015; Harris et al. 2017b; NAS 2017; Farmer et al. 2018).

There is no AFTT activity involving sonar, air guns, or explosives that is both long in duration (more than a day) and concentrated in the same location (e.g., within a few square miles). Given the dispersed nature of the proposed AFTT sonar use in space and time, we would expect that in most instances individual whales could compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. Similarly, long-term or chronic physiological stress responses that could result in fitness consequences are not anticipated given the types of acoustic sources and their spatial and temporal distribution throughout the action area.

Energetic costs to exposed individuals may be greater during MTEs and other large-scale military events that occur over multiple days (to weeks), over large ocean areas and involve

multiple sonar platforms. During such events, cessation of foraging may last longer and whales may need to travel farther distances to resume foraging behaviors. However, there is a low likelihood that large whales and military readiness activities would co-occur for extended periods of time or repetitively over the duration of an activity or event. Mitigation measures that will be implemented by the Action Proponents as part of the proposed action may further reduce the likelihood of this occurring. As discussed in Section 6.1.1, large whales may be more susceptible to masking from continuous or high-duty cycle active sonar sources noise, which may cause disruptions to communication that can, in turn, result in a behavioral response. Blue, fin, sei, and sperm whales will likely be exposed to continuous active sonar at levels that could result in masking effects, which could lead to behavioral disruptions to communication, social interactions, and foraging (sperm whales). While there is a lack of data on behavioral responses of mysticetes to continuously active sonars, these species are known to be able to habituate to novel and continuous sounds (Nowacek et al. 2004), suggesting that they could have similar responses to high duty cycle sonars. In summary, the available information indicates a range of behavioral responses to sonar may occur, but most responses are expected to be brief, with the animal returning to baseline behavior shortly after the exposure is over.

The duration and magnitude of the proposed activity is important to consider in determining the likely severity, duration, and potential consequences of exposure and associated response to impulsive sounds such as explosives and air guns. Significant behavioral responses are not anticipated from solitary explosions due to the extremely short duration of acoustic exposure from such explosions. Military readiness activities involving multiple explosions over a short time could result in significant behavioral responses. Significant behavioral responses from air guns would be very rare (i.e., only predicted for fin whales; less than one per year) due to the characteristics and limited use of this acoustic stressor as part of the proposed action.

Mysticetes seem to be the most sensitive taxonomic group of cetaceans to impulsive sound sources, with possible avoidance responses occurring out to 30 km and vocal changes occurring in response to sounds over 100 km away. Responses appear to be behaviorally mediated, with most avoidance responses occurring during migration behavior and little observed response during feeding behavior. These response patterns are likely to hold true for AFTT impulsive sound sources. However, the proposed impulsive sources would largely be stationary and short-term (i.e., instantaneous for explosives) as compared to sources in experimental studies, and so responses to military impulsive sounds would likely occur in closer proximity or not at all. The activity-based mitigation measures and mitigation areas that would be implemented for AFTT Phase IV may further reduce the potential for significant behavioral responses to occur from exposure to explosions and air guns.

Bioenergetic Models of Marine Mammal Responses to Acoustic Stressors

The long-term consequences due to individual behavioral reactions, instances of physiological stress, or auditory impacts can be difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. To

evaluate the potential consequences of behavioral responses and stress to affected animals, one should consider the context of the exposure and response scenario including the following: 1) the duration of the exposure and associated response, 2) whether or not repeated exposures would be expected, 3) the behavioral state of the animal at the time of the response, and 4) the health of the animal at the time of the response.

In recent years, population models have been developed, within the ONR Population Consequences of Disturbance (PCoD) framework (Pirrotta et al. 2018), to link short-term effects to individuals due to anthropogenic stressors with long-term consequences to both the exposed individuals and the marine mammal populations they represent. PCoD models have been used to forecast the possible consequences of a range of disturbance scenarios (Keen et al. 2021). Farmer et al. (2018) developed a bioenergetics framework to examine the impact of foraging disruption on body reserves of individual sperm whales. The authors examined rates of daily foraging disruption to predict the number of days to terminal starvation for various life stages, assuming exposure to seismic surveys. Mothers with calves were found to be most vulnerable to disruptions. Pirrotta et al. (2021) developed a bioenergetic model to predict effects from military active sonar on a blue whale's daily energy intake. Activity budgets and movements were highly variable in space and time and among individuals, resulting in large variability in predicted energetic intake and costs. A portion (11%) of those simulated whales had negative net energy even after brief (e.g., 6 to 30 minutes) or weak (e.g., 160 to 180 dB re 1 μ Pa source level) events, which indicated that they would not be able to cover that day's energetic cost. This study suggests that context can be an important predictor of the energetic costs of sonar disturbance. Czapanskiy et al. (2021) modeled energetic costs associated with behavioral response to mid-frequency active sonar using datasets from 11 cetaceans' feeding rates, prey characteristics, avoidance behavior, and metabolic rates. They found that the short-term energetic cost was influenced more by lost foraging opportunities than increased locomotor effort during avoidance, and that mysticetes incurred more energetic costs than odontocetes, even during mild behavioral responses to sonar. Pirrotta et al. (2022a) integrated results from a decade of multidisciplinary research to quantify the effects of military sonar activities and potential future environmental changes on the vital rates of blue whales. Their model predicted that environmental changes would severely affect vital rates, while the current regime of sonar activities would not, despite individuals changing their behavior in response to sonar exposure (Southall et al. 2019a). Migrating humpback whale mother-calf pairs' responses to seismic surveys were modeled by Dunlop et al. (2021). The results demonstrated that migrating whales would not likely experience enough of a delay as a result of disturbance to result in population consequences, but whales disturbed in breeding or resting areas would be more vulnerable to consequences of disturbance. Keen et al. (2021) summarized information from marine mammal PCoD models and highlighted essential intrinsic and extrinsic factors to consider when assessing likely consequences to individuals and marine mammal populations from anthropogenic stressors, including acoustic impacts (Figure 59). Here, we consider how these factors relate to the marine mammal species

affected by the proposed action in terms of potential long-term consequences from acoustic and explosive impacts.

Marine mammal movement patterns broadly fall into three categories: resident, nomadic and migratory. Species that exhibit migratory movement patterns transit annually or seasonally between sites within their range; species that exhibit resident movement patterns occupy small home ranges relative to the population's overall range; and nomadic species move over much of the population's range without spatial or temporal consistency. Whereas most large whales (including those considered in this opinion) exhibit migratory movement patterns, Rice's whales are a resident species within the Gulf of America, where they live year-round. The exposure potential for resident species is year-round and the risk of repeated impacts on individuals is likely similar within the population as animals move throughout their range (Keen et al. 2021). Because foraging grounds and reproductive areas spatially overlap for resident populations, the behaviors potentially disrupted will depend on the timing of the disturbance event (Gallagher et al. 2021). The other large whale species affected by the proposed action are migratory: they winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed. In general, the exposure potential for migratory species is seasonal as this movement pattern reduces the potential for year-round, prolonged exposure from a particular disturbance-inducing activity in a given area. However, for actions that cover a large geographic area, such as AFTT, migratory species could potentially be exposed to anthropogenic disturbance both on their foraging grounds, within migratory corridors, and, in the case of North Atlantic right whales, on their calving grounds. While the proportion of the population exposed will be high during synchronous migrations, individual exposure levels will be relatively low because individuals generally transit quickly.

Other life history traits considered in bioenergetic models include reproductive strategy, body size, and pace of life (Figure 59). The large body size and slow pace of life of the mysticetes considered in this opinion may be valuable in buffering against periods of reduced food availability. With the exception of Rice's whales, all of the ESA-listed mysticetes affected by the proposed action are considered capital breeders because they store energy prior to parturition and lactation. Capital breeders rely on high seasonal productivity to accumulate sufficient energy during a compressed feeding season to support calf production and have distinct feeding and calving seasons and habitats (Garrison et al. 2024b). Capital breeders are less sensitive to short-term foraging losses, particularly during the lactation period, because they rely on energy that has already been stored (Pirotta et al. 2019). However, capital breeders may not be able to accumulate sufficient energy for successful reproduction if disturbance within important foraging areas is prolonged, or if the available foraging habitat is spatially limited (Costa et al. 2016).

In contrast, Bryde's-like whales, including Rice's whales, are best characterized as 'income breeders' that rely upon consistent prey resources throughout the year to support the energetic costs of reproduction (Constantine et al. 2018; Izadi et al. 2018). An income breeding strategy may make Rice's whales more susceptible to repeated short-term foraging losses over time.

life-history traits	movement ecology	– resident: individuals occupy small home ranges compared to population's range, year-round and prolonged exposure potential – nomadic: individuals move over population's range without spatial or temporal consistency, year-round and unpredictable exposure potential – migratory: individuals undertake annual or seasonal movements between sites within population's range, seasonal exposure potential – demographic: age, sex, and reproductive status influence spatial and temporal movements
	reproductive strategy	– income breeder: feeds during lactation, vulnerable to prolonged foraging loss during lactation – capital breeder: stores energy prior to parturition for lactation, vulnerable to prolonged foraging loss during gestation
	body size	– body size: a larger body size may buffer against periods of reduced prey availability – life stage: juveniles and young mothers may be more sensitive to reduced food availability due to physiological constraints related to body size
	pace of life	– fast pace of life: reproduction is more sensitive to reduced or lost foraging, but populations will be quicker to recover due to high reproductive rates and short generation times – slow pace of life: reproduction is more resilient to reduced or lost foraging, but populations will be slower to recover, particularly if adult survival is impacted, due to low reproductive rates and long generation times
disturbance source characteristics	overlap with biologically important habitats	– the effect of disturbance is strongly influenced by whether it overlaps with biologically important habitats when individuals are present – avoiding biologically important habitats will provide opportunities for individuals to compensate for reduced or lost foraging if large portions of their range are disturbed
	duration and frequency	– continuous disruption will have a greater impact than intermittent disruption – reducing the duration and frequency of disturbance or incorporating breaks between disturbance events may allow individuals to recover – energy loss can be translated into days of disturbance to inform area- or population-specific disturbance caps
	nature and context	– the probability and severity of individual responses depends on the interactions between the type and nature of the disturbance source and the context of the exposure – incorporating context into risk assessments can significantly reduce the uncertainty in managing populations and mitigating effects
environmental conditions	natural variability in prey availability	– sensitivity to disturbance strongly depends on the availability of prey in the environment – avoiding periods of low productivity and increased energy intake can reduce the potential for interactive and cumulative effects
	climate change	– climate vulnerability assessments can help identify populations most vulnerable to climate change and the factors contributing to their vulnerability – climate change coupled with disturbance may have interactive and cumulative effects that affect reproductive success and survival

Figure 59. Intrinsic and Extrinsic Factors to Consider when Assessing Likely Consequences to Individuals and Marine Mammal Populations from Anthropogenic Stressors (Keen et al. 2021)

Sperm whales, compared to other large whales, may also be less resilient to short-term foraging losses due to their income-breeding strategy (Keen et al. 2021), coupled with the physiological properties of their blubber (i.e., the vast majority of their blubber lipids are stored as wax esters,

a less accessible source of metabolizable energy, rather than as triacylglycerols) (Koopman 2007).

The physiological constraints of body size may also affect how individuals in early life stages respond to disturbance. Juveniles and younger (i.e. smaller) mature females are considered the most sensitive groups within a population. Our exposure analysis did not quantify AFTT impacts across the different life stages that could potentially be exposed. However, considering the species' life histories and the degree of overlap between the proposed action and species' ranges, the species with early life stages that could potentially be most at risk are Rice's whales and North Atlantic right whales.

An individual's propensity to respond and the severity of the response likely depend on additional intrinsic factors that can influence the effect of disturbance on individual health and vital rates. These may include species, sex, age class, body condition, and contextual factors such as current behavioral or energetic state. When considering the potential consequences of exposure and response to military sonar, we must also take into account the health of the individual animal affected. Individuals that are in good health, with sufficient energy reserves, are likely to be much more resilient when faced with long-term or repeated disturbance than an animal in poor condition. Marine mammal behavioral research has indicated that many species including humpback whales (Silve et al. 2016), blue whales (Goldbogen et al. 2013), and sperm whales (Isojunno et al. 2016) may disrupt foraging when exposed to anthropogenic noise. If the animals are not able to make up for lost foraging opportunities due to such exposure, this could have consequences on the affected animal's available energy supply. For individuals in good health, with sufficient energy reserves, such a reduction could likely be compensated for at a later time, provided the animal is not subject to sustained disruption. However, for individuals in a compromised state, a reduction in available energy has a higher likelihood of being consequential, depending on the duration of the disruption (i.e., long duration disruptions would have a higher likelihood of being consequential).

For most of the marine mammal species that will be impacted by AFTT sonar and explosive activities in the action area, we do not have information to suggest affected animals are likely to be in a compromised state at the time of exposure. Known exceptions to this would be for individual whales that have either been exposed to entanglement in fishing gear or a nonlethal vessel strike. In general, there is evidence that North Atlantic right whales are experiencing a population-wide decline in health (Rolland et al. 2016; Pace et al. 2017). Therefore, some individual North Atlantic right whales exposed to AFTT sonar and explosives could already be in a compromised state. Entanglement in fishing gear and vessel strike have been identified leading causes of North Atlantic right whale mortality and factors inhibiting recovery of the species (Knowlton et al. 2012). Further discussion of the effects of these stressors on large whales in the action areas can be found above in the Environmental Baseline: Section 5.8.2 Marine Mammal Fishery Interactions and Section 5.11 Vessel Strike.

Also important to consider is an animal's prior experience with a sound source. Given their longevity, the majority of large whales exposed to sound from AFTT training and testing activities have likely been exposed to such sources previously as these activities have been occurring in the action area for decades. Harris et al. (2017a) suggested that processes such as habituation, sensitization, or learning from past encounters may lead to stronger or weaker reactions than those of a naïve animal. For example, Baird et al. (2017) found no large-scale avoidance by false killer whales of areas with relatively high mid-frequency active sonar use on the PMRF. The authors suggested that since sonar had been used at the PMRF for over 30 years, it was likely that animals in this area had been exposed to sonar multiple times on previous occasions. The authors suggested that more naïve populations may be more likely to exhibit avoidance responses if exposed to sonar.

An individual's sensitivity to a disturbance-inducing activity is also affected by the characteristics of the disturbance source, including the spatial and temporal features and nature of the disturbance source (e.g. type, intensity, frequency, moving versus stationary), which can interact with life-history traits and other contextual factors to influence the probability and severity of individual responses (Ellison et al. 2012; Keen et al. 2021). A population's sensitivity to disturbance will be strongly influenced by the importance of the disturbed area for foraging, reproduction, and migration. While it is difficult to predict exactly what a marine mammal may be doing at the time of exposure, we can make some predictions based on time of year and the location of the animal at the time of exposure, where such information is available. For example, if a behavioral response occurs in foraging critical habitat, the expectation is that feeding would be interrupted in some manner; if a behavioral response occurs in calving critical habitat, the expectation is that activities associated with calf rearing (e.g., nursing young, resting) would be disrupted.

In our exposure analysis above, quantitative impacts based on NAEMO are partitioned by area type for anticipated impacts in critical habitat or BIAs. Of the migratory large whale species in the action area, the North Atlantic right whale is the only species that could be exposed to acoustic stressors in known reproductive areas. Rice's whales are not migratory, but we have little information on the location of their reproductive areas within the Gulf of America. While significant behavioral responses and TTS are predicted to occur within right whale calving critical habitat, the relative number and proportion of impacts in this area is small (as compared to all right whale impacts) due to mitigation measures (Section 2.3.2) designed to minimize exposure to acoustic and explosive stressors. Rice's whales could also be exposed to acoustic and explosive stressors within their reproductive areas, although the location of such areas is still unconfirmed for this species. North Atlantic right whales are also likely to be exposed to acoustic and explosive stressors in important foraging areas, including designated critical habitat and BIAs in various locations along the Northeast Atlantic coast. A relatively small number of significant behavioral responses and TTS are also predicted to occur within BIAs identified as important foraging grounds for fin and sei whales in the Gulf of Maine and off Montauk Point (for fin whales).

The temporal features of disturbance also greatly influence the extent to which vital rates are impacted by acoustic stressors (Keen et al. 2021). Reducing the duration and frequency of disturbances can help mitigate any energetic consequences by allowing individuals to regain energy reserves. As discussed above, most AFTT activities involving sonar or explosives are short in duration (i.e., less than one day) and do not occur with any regularity in a given location. For longer duration events (e.g., MTEs), acoustic and explosives stressors would generally be dispersed over large ocean areas, thus reducing the likelihood of prolonged or persistent exposure to individual whales. Farmer et al. (2018) found that less frequent disturbance provided opportunities for sperm whales to compensate for missed foraging, with the time to terminal starvation being roughly inversely proportional to the frequency of the disturbance event. Our exposure analysis above (Section 6.1.1, Tables 55 through 61) shows the estimated average annual number of exposures (i.e., behavioral responses, TTS and AINJ combined) per individual based on the population abundance estimate and the NAEMO exposure estimates. For blue, fin, sei and Gulf of Mexico stock of sperm whale, the estimated average annual number of exposures per individual is less than one. For the other species, the average annual number of exposures per individual ranges from 1.24 (North Atlantic right whale) to 2.9 (North Atlantic stock of sperm whale). Although some individual whales will be exposed more often (and some will not be exposed at all) in a given year, these average annual exposure estimates provide some indication of the frequency that most individuals would likely be exposed to acoustic and explosive stressors.

6.1.2 Vessel Strike Analysis

Vessel strike remains a high risk threat and is a primary cause of mortality and injury for many ESA-listed large whale species. In this section, we analyze the effects of vessel strike to ESA-listed large whales as a result of the proposed action.

Exposure Analysis

We start our vessel strike exposure analysis by reviewing the recent history of military vessel strikes involving large whales in the action area, the particular circumstances surrounding those strikes, and how information on past vessel strikes can inform our analysis for this consultation. Next, we consider the risk factors that affect the probability of a large whale vessel strike, and how they relate to the proposed action. We then describe the proposed mitigation measures for minimizing the risk to large whales from vessel strike, and discuss the anticipated effectiveness of those measures. Based on an analytical approach developed for the reinitiated Navy HSTT Phase III biological opinion (NMFS 2024f), we present an updated AFTT large whale vessel strike probability quantitative analysis for Phase IV. Our quantitative analysis considers vessel strike of large whales comprehensively, as a result of all Action Proponent vessel movement throughout the action area, as opposed to in the context of specific training or testing exercises. Finally, we consider application of our quantitative analysis to our overall exposure analysis in light of the recent history of military vessel strikes, context-specific risk factors, and mitigation measures that are part of the Action Proponents' proposed action.

Recent History of Military Vessel Strikes of Large Whales in the AFTT Action Area

From 1995 to 2024 there were a total of 19 Navy vessel strikes reported in the AFTT action area. The maximum number of Navy vessel strikes reported in any given year in the AFTT action area was three strikes, which occurred in 2001 and 2004. The three most recent Navy strikes reported occurred in 2011 (1) and 2012 (2). All three of these strikes occurred in the VACAPES Range Complex (including one inshore in the Lower Chesapeake Bay), but none were identified by species (Navy 2024a). The 2011 strike occurred on June 9th approximately 75 NM east of Cape Henry, Virginia. The 2012 strikes occurred on February 2nd, in the vicinity of Cape Henry, and October 27th, 24 NM east of Norfolk, Virginia. No large whale vessel strikes have been reported by the Navy in the AFTT action area since 2012 (Cowan 2024).

The Coast Guard reported striking three large whales in the AFTT action area from 2009 to 2024, all within the VACAPES Range Complex: two in 2009 and one in 2024. In December 2009, two North Atlantic right whales were struck by an 87-ft Coast Guard patrol boat off Cape Henry, Virginia (Navy 2024a). Vessel crew noted that the animals were observed swimming away without apparent injuries. The strikes occurred while the patrol boat was escorting Navy assets. In May 2024, a whale was struck east of Cape May, New Jersey. Although the struck whale could not be identified by species, based on sightings of humpback whales in the area prior to the interaction, it is likely this was a humpback whale strike (Navy 2024a).

For purposes of our analysis, we assume that the large whale vessel strikes described above represent a complete record of recent Action Proponent vessel strikes within the action area. Whereas reported or documented whale strike incidents involving commercial vessels likely represent a small fraction of actual commercial vessel strikes since they are not required to report them (NMFS 2011b; Carretta 2021), the Action Proponents remain confident that their ability to detect whale strikes as they happen is effective, and reporting to NMFS is an accurate record of Action Proponent strikes. This is based on the higher manning on military ships (bridge watch team including dedicated Lookouts, deck personnel, etc.), standard operation procedures, mitigation measures, reporting requirements, and marine species awareness training (Navy 2021). Although we have no information that it has happened in the past, there is the possibility that an unmanned Navy vehicle could strike a large whale. The Navy has indicated that most AFTT USV and UUV activities will have support vessels with observers in line of sight during testing, which will aid in visual detection if a strike were to occur. In some circumstances, USVs may be manned, during which time Lookout duties will transfer to the USV in accordance with requirements for other Navy surface vessels. In addition to Lookouts, USVs and UUVs are equipped with sensors and/or sonar systems that detect anomalous movement and objects and are used for object avoidance. When the onboard systems detect a strike of any kind, the personnel will immediately stop the platform to investigate.

In some instances, a struck whale can become attached or impinged to a feature on the vessel's hull and may not be detected when the strike occurs. While this is more common with large

commercial vessels, in 2021 an Australian Navy military vessel came into port in San Diego with two fin whales lodged on the sonar dome in the bow of the vessel. The Navy has indicated that it would be implausible for a marine mammal to become lodged on the sonar dome of a U.S. Navy ship and remain undetected because of a technological standard operating procedure (Navy 2021). Sonar domes on U.S. Navy ships have a pressurized rubber window that maintains 150 PSI through the ships fire main. If anything affects the pressure, an alarm sounds alerting personnel that something had hit the sonar dome. The shape, hydrodynamic design, construction using a non-abrasive material, and regular hull cleaning procedures to remove barnacles and other growth on U.S. Navy ships are also reasons that it is highly unlikely a whale could become lodged on a U.S. Navy ship's sonar dome (or other part of the bow) and remain undetected (Navy 2021).

Large Whale Vessel Strike Risk Factors

The relative risk of a large whale vessel strike within a particular area is primarily a function of animal density and the magnitude of vessel traffic (e.g., Fonnesebeck et al. 2008; Vanderlaan et al. 2008). The density of large whales in areas with concentrated vessel activity can vary significantly by species, time of year, and over time with changing environmental conditions (e.g., temperature, prey availability). Other factors, such as vessel speed, size, and maneuverability can also influence both the probability of a vessel strike occurring and the outcome (i.e., minor injury, serious injury, mortality) when a strike occurs. In this section, we focus on the factors affecting vessel strike risk as they relate to the proposed action. We will consider the factors that could affect the outcome of a vessel strike that could result from the action, in our response analysis below (Section 6.1.2). For a more general discussion of vessel strike risk from past and present activities in the AFTT action area, including military and non-military vessels, we refer the reader to Section 5.11 of the Environmental Baseline.

Most military readiness activities involve vessel movement. Vessel strikes to large whales are not associated with any specific training or testing activity but rather a limited, sporadic, and accidental result of vessel movement in the action area. Vessel movement can be widely dispersed throughout the action area, occurring in both offshore and inshore water areas. Physical disturbance from large vessels would be more likely in the continental shelf portions than in the open ocean portions of the action area because of the higher concentration of large vessel movements in those areas.

Military readiness activities that include vessel movements in the offshore waters of the action area would primarily be conducted in the VACAPES Range Complex, Navy Cherry Point, and JAX Range Complexes (see Figure 2 above), but would also be conducted in the Northeast, Key West, and Gulf Range Complexes, the Naval Undersea Warfare Center Newport Testing Range, the Naval Surface Warfare Center Panama City Division Testing Range, the South Florida Ocean Measurement Facility, as well as other offshore AFTT areas (Navy 2024c). Offshore vessel movements would be widely dispersed throughout the action area, but are more concentrated

near ports, naval installations, range complexes and testing areas. Large vessel movement primarily occurs in the U.S. EEZ, with the majority of the traffic flowing between Naval Stations Norfolk and Mayport (Navy 2024c). The use of small crafts associated with training activities within inshore waters would occur on a more regular basis than offshore large vessel use, and typically involve high speed (greater than 10 knots) vessel movements. However, inshore waters are generally more confined waterways where ESA-listed large whale species considered in this opinion do not typically occur.

Based on historical vessel traffic data for large surface vessels (i.e., vessels > 65 ft) from 2009 to 2023 (Navy 2024a), the Action Proponents estimate that the proposed action would include an annual average of approximately 2,800 Navy vessel and 1,750 Coast Guard vessel at-sea days throughout the AFTT action area. The large majority (about 98% of Navy and 84% of Coast Guard) of AFTT vessel traffic will occur in the Atlantic Ocean portion of the action area (Navy 2024a). Combined, Action Proponent vessels represent a relatively small proportion (about 1%) of the overall vessel activity in the action area.

Vessel size is also an important predictor of large whale vessel strike risk. In general, longer vessels have deeper drafts, and the weight (e.g., cargo load) of a vessel can impact how deep it sits in the water. The draft of a vessel can influence strike risk to whales both because deeper drafts overlap more in space with the depth range of whales and because deeper drafts make it more difficult for a whale to evade a strike as they must dive deeper to avoid an oncoming vessel. Larger vertical "risk zones" occur due to a vessel's draft and propeller suction depth. In waters less than 33 m deep, these zones can trap whales, as they lack the depth to dive and escape (Blondin et al. 2025). In addition, if a strike occurs, the probability of a lethal outcome is significantly greater from a very large vessel (Garrison et al. 2024a). Based on their North Atlantic right whale vessel strike encounter risk model, Blondin et al. (2025) predicted that ocean-going vessels (i.e., > 350 ft) account for 78% of lethal strikes, whereas small/medium vessels (< 65 ft) account for about 10% of lethal strikes.

Vessel strikes of large whales by military vessels typically involve very large vessels (i.e., > 350 ft) such as cruisers, destroyers, and aircraft carriers. However, as noted above, in 2009 an 87-ft Coast Guard patrol boat struck two North Atlantic right whales off Virginia (Navy 2024a). In general, smaller military vessels have greater maneuverability, which allows them to change course more quickly to avoid a collision once a whale has been seen. Lookouts may also be more effective at spotting whales within the full 360° radius mitigation zone on smaller vessels as compared to larger vessels (although the vessel configuration and location and number of Lookouts would also be factors).

In addition to the volume of vessel traffic and vessel size, a correlation between vessel speed and the risk of striking a whale has been shown in several studies. Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. Jensen and Silber (2003) analyzed 292 records of known or probable ship strikes (inclusive of military and non-military vessels) of all large whale species from 1975 to 2002. Of

the cases where vessel speed at the time of collision was reported (n=58), about two-thirds resulted in serious injury (n=19) or death (n=20). While reported operating speeds at the time of strike ranged from 2 to 51 knots, the majority (79%) of vessels that struck various species of large whales reported speeds of 13 knots or greater.

Rockwood et al. (2021) developed a ship strike model using whale density data and automatic identification system (AIS) vessel data to estimate mortality under different management scenarios in the Santa Barbara Channel, California. Their results showed that if 95% cooperation with the voluntary vessel speed reduction recommendation occurred in the shipping lanes, whale deaths there would decrease by 22% to 26%. Rockwood et al. (2020) studied the effectiveness of speed reduction measures for decreasing whale-strike mortality in shipping lanes off San Francisco, California. They predicted that if 95% of mariners adhered to the recommended 10 knot limit in the shipping lanes, twice as many blue whale and three times as many humpback whale deaths would be avoided relative to current adherence to this voluntary limit. Similarly, results from a study by Redfern et al. (2019) suggest that a large decrease in ship-strike risk can be achieved by speed reductions throughout the Southern California Bight.

Crum et al. (2019) modeled vessel strike risk to North Atlantic right whales before and after implementation of time-area vessel speed restrictions. They found that the expected seasonal mortality rates of right whales decreased by 22% on average after the speed rule was implemented, indicating that the rule is effective at reducing lethal collisions. By comparison, Conn and Silber (2013) estimated that vessel speed restrictions reduced North Atlantic right whale ship strike mortality risk levels by 80% to 90%. The primary difference between the two models is that Conn and Silber (2013) measured the effect of vessel speed on a process that combined the encounter rate and avoidance rate, whereas the Crum et al. (2019) model considered these as separate processes. Thus, we would expect the reduction in vessel strike mortality rates due to vessel speed restrictions to be greater if whales exhibiting avoidance behavior are more susceptible to collisions (i.e., reduced ability to avoid a nearby vessel) with faster moving vessels. In some scenarios, slower vessels may allow whales increased opportunities for avoidance due to a combination of maneuverability and detection (Gende et al. 2019). A faster vessel will travel a greater distance compared to a slower moving vessel over a set period of time, such as when whales are submerged between surfacing events, on deep dives, or during time lags related to decision-making and communications on the bridge following detection (Gende et al. 2019). These factors can all result in an increased susceptibility of large whales to vessel strike with increasing vessel speed.

Vessel speed can also influence whale avoidance by influencing detection probability. Case studies of large whale behavioral avoidance suggest that blue whales may respond to close encounters with large vessels by altering their diving behavior rather than moving horizontally at the surface (McKenna et al. 2015; Szesciorka et al. 2019). In one case study of a close vessel encounter with a blue whale, Szesciorka et al. (2019) noted that the ship's reduced speed (i.e.,

11.3 knots) may have played a role by giving the whale enough time to respond to the nearby vessel. A behavioral dive response may not be as effective at avoiding vessels traveling at higher speeds (McKenna et al. 2015). Higher vessel speeds increase the risk that a whale could have been struck at the surface or get close enough to the ship's draft that the propeller suction effect created by the ship's hydrodynamic flow could pull the whale toward the hull (Szesciorka et al. 2019). In general, vessels transiting at high speeds will produce more noise than vessels transiting at low speeds, thus increasing the whale's ability to avoid an encounter. However, many military vessels are strategically designed to be quieter than similar sized commercial vessels, which may reduce the available reaction time for large whales to avoid a vessel interaction.

Military vessels generally transit at speeds that are optimal for fuel conservation or to meet operational requirements (Navy 2024c). Large Navy surface vessels (>59 ft) generally operate at average speeds of between 10 and 15 knots. While these speeds are considered averages and representative of most events, some vessels need to operate outside of these parameters during certain situations. Large vessels may occasionally be required to operate at speeds that are higher than normal operating speeds, which may pose a greater strike risk to large whales because there would be less time for the vessel crew to detect a large whale and maneuver to avoid a strike, and there would be less time over a given distance for the animal to react and avoid the vessel. For example, to produce the required relative wind speed over the flight deck for take-off and landings, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly.

For the proposed action, there are a few specific offshore events, including high-speed tests of newly constructed vessels, where vessels would operate at higher speeds. Propulsion testing, which sometimes includes ships operating at speeds in excess of 30 knots, and use of large high-speed unmanned surface vessels may pose a higher strike risk because of the high speeds at which some vessels need to operate to complete the testing activity (see Section 2.4.4 for details on propulsion testing). Smaller military vessels (i.e., <50 ft), which are all support craft, typically have much more variable speeds (0 to 50+ knots, dependent on the mission) compared to large vessels. High speed movements of smaller vessels during inshore operations could occur more frequently. However, given the location (inshore or nearshore) and maneuverability of smaller vessels, the risk of a large whale vessel strike in such scenarios would be much lower than the strike risk from a large vessel operating in offshore portions of the action area at high speeds.

A whale's behavioral state has been shown to influence the context-dependent behavioral response to acoustic stressors, including vessel noise. Feeding whales may be distracted and thus be less capable of detecting and avoiding approaching vessels (Szesciorka et al. 2019). Mother-calf pairs have greater energetic requirements than other age and social classes and, therefore, are likely affected by approaching vessels in ways that are not immediately apparent (Smultea et al. 2022). Smultea et al. (2022) observed a blue whale mother and calf's behavioral response to an approaching small recreational vessel in the Southern California Bight. The calf first approached

the vessel while it was stationary, and then quickly swam away when the vessel started to move. Maximum spacing between the mother and calf increased from about 25 to 50 m when the vessel was present. The observed behavioral avoidance of the vessel by the calf once the vessel started moving, which was associated with an increase in speed at the water surface, matches other reports of blue whales exhibiting fleeing responses to vessel disturbance, which are similar to flight responses by blue whales during observed predator attacks (Ford and Reeves 2008).

Related to behavioral state is the whale's depth distribution (i.e., proportion of time spend at or near the surface), which can affect the probability that a whale depth is within the draft of a vessel, as well as the animal's ability to avoid being struck by a vessel (Blondin et al. 2025). North Atlantic right whales are particularly vulnerable to vessel strike because they spend a large proportion of their time just beneath the surface; i.e., within the draft of large vessels but often not visible to mariners. Blondin et al. (2025) reported that right whales in the Southeast calving grounds, Cape Cod Bay feeding grounds, and Mid-Atlantic migratory/feeding areas spend between 93% to 97% of their time within 15 m of the surface. In contrast, in the U.S. Northeast feeding grounds (excluding Cape Cod Bay) they spend only about 59% of their time within 15 m of the surface. The Northeast and Cape Cod Bay regions are both characterized by foraging behavior, but the particular foraging technique used differs between the regions given differences in depth and the availability of preferred prey, *Calanus* copepods (Blondin et al. 2025). This study suggests that, in addition to whale density, vessel density and speed, the relative risk of a vessel strike can vary greatly, both temporally and spatially, depending on numerous contextual factors related to the whale's behavioral state.

The operation and configuration of Action Proponent large military vessels (>18 m (59 ft)) within the action area differ from commercial merchant vessels in ways that may reduce the risk of striking a large whale. Many Action Proponent ships have their bridges positioned closer to the bow, offering better visibility ahead of the ship (compared to a commercial merchant vessel). The crew sizes on large military vessels are generally larger than merchant ships, allowing for stationing more trained Lookouts on the bridge and in other locations. There are often aircraft associated with AFTT activities, which can serve as additional lookouts for detecting cetaceans in the vicinity of a vessel or ahead of a vessel's present course before crew on the vessel would be able to detect them. Military vessels would also likely be more maneuverable in avoiding large whales spotted in the path of the vessel than commercial merchant vessels due to their quicker rudder responses, resulting in a turning radius that is typically smaller compared to commercial ships.

Vessel Strike Mitigation Measures

Ongoing AFTT Phase III mitigation measures implemented to reduce the risk of vessel strike that will be continued into AFTT Phase IV include the following:

- Required training for watchstanders and Lookouts to improve the effectiveness of visual observations for marine mammals and sea turtles;
- Activity-based mitigation involving the use of Lookouts to maintain minimum distances to marine mammals when a vessel is underway;
- Mitigation for vessels within the Northeast North Atlantic Right Whale Mitigation Area to obtain sightings information from the North Atlantic Right Whale Sighting Advisory System and implement speed reductions in certain circumstances (Table 18);
- Seasonal mitigation within the Jacksonville Operating Area North Atlantic Right Whale Mitigation Area to minimize potential vessel interactions by using Early Warning System sighting data for event planning and transiting (Table 20);
- Seasonal mitigation in the Southeast North Atlantic Right Whale Mitigation Area to reduce the time ships spend in the highest seasonal occurrence areas and to reduce speeds after they observe a right whale, if they are within 5 NM of an Early Warning System sighting reported within the past 12 hours, and at night and in restricted visibility (Table 21);
- Mitigation within the Dynamic North Atlantic Right Whale Mitigation Area to help inform visual observations during military readiness activities that involve vessel movements (Table 23); and
- Mitigation in other designated marine mammal mitigation areas that limit the use of Navy sonar and/or explosives, either seasonally or year-round, in areas with high densities of marine mammals.

These mitigation measures are all described in detail in Section 2.3.2 of this opinion. New (or modified) vessel strike mitigation measures that the Action Proponents will implement for Phase IV include:

- Restricting or avoiding high-speed vessel propulsion testing events in some areas where North Atlantic right whales and Rice's whale are more likely to be at risk of vessel strike;
- Inclusion of the WhaleMap web address and additional language regarding vessel strike risk in the PMAP reports generated for activities in the Dynamic North Atlantic Mitigation Area;
- Issuance of an annual awareness message for Action Proponent vessels that routinely operate in the Rice's whale proposed critical habitat advising that risk of whale strike is increased when transiting through critical habitat (i.e., within the 100 to 400 m isobaths), particularly at night or during periods of restricted visibility;
- Additional Lookouts on some Navy ships;
- Improvements to Lookout training materials; and
- Revised language in the Vessel Movement activity-based mitigation measure (Table 8) to specify that maneuvering to maintain distance from marine mammals may include reducing speed.

In addition to the measures above, the Action Proponents have agreed to an adaptive management measure regarding the use of NMFS's North Atlantic right whale persistence models for mitigation purposes within the first year of AFTT Phase IV implementation. Mitigation measures proposed by the Action Proponents to reduce the risk of vessel strike are not factored into our quantitative exposure analysis (see *Vessel Strike Probability Calculation*, below), but are considered qualitatively in our effects analysis.

Navy Lookouts and bridge watch teams are required to maintain a 500-yd mitigation zone around whales, to avoid approaching any whale head-on, and to maneuver the vessel to maintain distance (when safe to do so) if a whale is observed within the zone. The Navy updated their navigation instructions in 2018 to require three Lookouts on Navy cruisers and destroyers (Navy 2021). This change occurred for increased safety navigation purposes in general, and was implemented after the 2018 AFTT biological opinion was issued. The effectiveness of the vessel movement mitigation measure in terms of reducing vessel strike risk is largely based on the Lookouts' ability to effectively monitor the mitigation zone. The results of Oedekoven and Thomas (2022) suggest that Navy Lookout Teams (including Lookouts and other crew members) fail to detect large whales within the designated mitigation zone a large proportion of the time (i.e., 85% undetected within 500 yds; 80% undetected within 200 yds). While the activity-based mitigation for vessel movement may provide some benefit in terms of reducing vessel strike risk when whales (or signs of whales) are detected, the anticipated high rate of undetected whales in close proximity to the vessel suggests that the overall effectiveness of this mitigation may be limited, particularly in certain situations.

As noted above, for AFTT Phase IV the Action Proponents have agreed to revise language in the Vessel Movement activity-based mitigation measure to specify that maneuvering to maintain distance from marine mammals may include reducing speed. While this new language highlights the importance of reducing speed as a vessel strike mitigation measure, it does not require vessels to reduce speed. This proposed change could reduce vessel strike risk, although at this time we do not have enough information (e.g., how often would vessels reduce speed after observing a large whale within the mitigation zone) to evaluate its effectiveness. In addition, as discussed above, the effectiveness of the vessel movement mitigation measure is directly linked to the effectiveness of Lookouts at observing large whales within the mitigation zone. Based on the results of Oedekoven and Thomas (2022), and recent Action Proponent whale strike history, in many instances large whales will not be observed by Lookouts in time to successfully implement the vessel movement mitigation measure.

In addition, maneuvering to avoid observed whales at the surface may inadvertently put the vessel on a collision course with undetected whales. Whales that spend a lot of time below the surface are particularly vulnerable to vessel strike because opportunities for Lookouts to detect them are more limited. This risk is compounded by high vessel speeds, which can affect both the ability of Lookouts to detect a whale, and the whale's ability to avoid being struck by the vessel.

The recent history of military vessel strikes suggests that in many instances, prior to being struck, the whale is either not seen until the last minute or not seen at all by the Lookout Team or other vessel crew. In a study quantifying behavior and collision risk of humpback whales surfacing near large ships in Glacier Bay Alaska, Helm et al. (2023) found that around half the time that whales ascended from depth and surfaced to breathe they went undetected in the 20-second period prior to the encounter period in which they were detected. Further, in a given 20-second period following initial detection, a whale was only visible to an observer stationed at the bow about one-third of the time, on average, that it was present at the surface (Helm et al. 2023). This study highlights the shortcomings of vessel strike mitigation that relies solely on maneuvering to avoid observed whales, because whales at the surface within the strike zone often go undetected.

Passive acoustic devices (e.g., remote acoustic sensors, expendable sonobuoys, passive acoustic sensors on submarines) can complement visual observations when passive acoustic assets are already participating in an activity. However, the use of passive acoustic devices is not a required mitigation measure, and the majority of time Navy or Coast Guard vessels are underway they are not actively using these devices. In addition, passive acoustic monitoring is only effective at detecting whales when they are actively vocalizing, and spatial precision based on a single receiving platform is low because whales typically have very large sound propagation ranges.

As discussed above (Section 2.2.3), foreign military vessels are not subject to the same vessel strike mitigation implementation requirements as the U.S. Navy or Coast Guard. Depending on the location of the foreign military vessel in relation to the U.S. territorial sea and its involvement in an AFTT U.S. Navy event, the Navy has indicated that it can either request (i.e., when within the territorial sea) or encourage (i.e., when beyond the territorial sea) the foreign vessel to follow the U.S. Navy's mitigation measures when participating in a U.S. Navy-led exercises. While, in practice, many foreign military vessels participating in AFTT activities within the action area would implement vessel strike mitigation measures that are similar to or the same as U.S. Navy measures, there is no guarantee that this would occur or that foreign military mitigation measures would be as effective at minimizing vessel strike risk as U.S. Navy mitigation measures. However, since we have no records of a foreign military vessel striking a large whale in the AFTT action area in the past, and foreign vessel activity makes up an extremely small proportion of military vessel activity in the action area, we find it extremely unlikely (i.e., discountable) that a foreign military vessel will strike a large whale as a consequence of the AFTT proposed action, even if it does not implement the mitigation required of the Action Proponents' vessels.

Vessel Strike Probability Calculation

Data from 2009 through 2024 were used to calculate the most current probability of a Navy or Coast Guard vessel striking a whale during AFTT Phase IV activities. This time frame was selected because it represents a period of standardized mitigation, monitoring, and reporting

requirements across AFTT at-sea range complexes, and full implementation of improved marine species awareness training and mitigation measures specifically designed to minimize large whale interactions with Action Proponent vessels. Thus, the period from 2009 through 2024 provides us with the most robust and representative time series available for estimating the future risk of vessel strike. We recognize that additional mitigation measures, as well as changes in other vessel strike risk factors (e.g., whale population abundances, distribution through space and time, oceanographic conditions, and ecological changes), could affect the reliability of this time series for predicting future vessel strike risk. These potential changes are evaluated in our summary exposure analysis section below.

From 2009 through early 2024, the Navy and the Coast Guard each reported three large whale strikes within the AFTT action area. These incidents were described in more detail above. Since the species could not be determined for any of the three Navy vessel strikes, these strikes could have included a combination of ESA-listed and non-listed species. Two of the Coast Guard vessel strikes during this time frame involved ESA-listed North Atlantic right whales, while the third was presumed to be a non-listed population (West Indies DPS) of humpback whale. The probability of a vessel strike to large whales is influenced by the amount of time at sea for Action Proponent vessels in the action area. The Action Proponents compiled information on historic at-sea days in the AFTT action area from 2009 through early 2024 based on a combination of positional vessel data records and other sources of vessel traffic information. This analysis only included at-sea days for Action Proponent vessels greater than 65 ft. As discussed above, larger vessels, in general, represent a much greater strike risk to whales (Blondin et al. 2025), and military vessels smaller than 65 ft have never reported a large whale strike in the AFTT action area. Therefore, we consider it extremely unlikely that an ESA-listed large whale strike by one of these smaller military vessels will occur as part of the proposed action.

The number of past Action Proponent vessel strikes are combined with the at-sea vessel days to calculate a vessel strike rate based on the 2009 through 2024 reporting period. Since Navy vessel at-sea days data were not available for 2009, we extrapolated the 2009 estimated at-sea days based on the average annual at-sea days from 2010 to 2015. Similarly, since Coast Guard vessel at-sea days data were not available for 2009 to 2015, we extrapolated the estimated at-sea days for these years based on the average annual at-sea days from 2016 to 2023. We included 2024 in our analysis to account for the Coast Guard vessel strike that occurred in May of that year. Since, at the time we conducted our analysis, vessel activity data was only available from the Action Proponents through 2023, we extrapolated the 2024 estimated at-sea days for Action Proponent vessels based on the average annual at-sea days from 2016 to 2023.

The estimated total number of vessel (>65 ft) at-sea days for 2009 to 2024 was 44,309 days for Navy vessels and 28,072 days for Coast Guard vessels. USV at-sea days are not included in this estimate because there is no historical data on large USV (i.e., >65 ft) activity within the AFTT action area. Historically, the USVs used in the AFTT action area were equivalent to small boats. While larger USVs (up to 328 ft) have been proposed for AFTT Phase IV, the Action Proponents

have indicated that the addition of at-sea days associated with the limited number of large USVs (i.e., >65 ft) being tested in AFTT would not be large enough to change the results of the quantitative vessel strike analysis.

Dividing the three reported strikes by vessel at-sea days for Navy and Coast Guard (i.e., 3/44,309 and 3/28,072) results in a strike rate of 0.000068 strikes per vessel at-sea day for Navy vessels and 0.000107 for Coast Guard vessels. Based on information provided by the Action Proponents, we assume that the average annual large vessel activity in the AFTT action area over the 7-year period of the MMPA permit (late 2025 through late 2032) and into the reasonably foreseeable future will be similar to historical vessel activity from 2009 to 2024. Given this assumption, we estimate the average annual number of large vessel (i.e., greater than 65 ft) at-sea days for AFTT Phase IV will be 2,769 for Navy vessels and 1,755 for Coast Guard vessels. Multiplying by seven, we estimate the number of large vessel (i.e., greater than 65 ft) at-sea days over the 7-year MMPA permit period will be 19,385 for Navy vessels and 12,282 for Coast Guard vessels.

The historic daily strike rate from above (0.000068 strikes per Navy vessel at-sea day; 0.000107 strikes per Coast Guard vessel at-sea day) was then multiplied by the estimated vessel at-sea days over the 7-year MMPA permit (19,385 days for Navy; 12,282 days for Coast Guard) to estimate the number of large whale strikes that could be anticipated over the next 7 years. This calculation predicts an estimated 1.32 Navy vessel strikes and 1.31 Coast Guard vessel strikes over the 7-year period from late 2025 through late 2032.

The probabilities of a specific number of strikes ($n=0, 1, 2$, etc.) over the 7-year period from late 2025 through late 2032 can be derived from a Poisson distribution. A Poisson distribution is often used to describe random occurrences when the probability of an occurrence is small, e.g., count data such as cetacean sighting data, or in this case strike data, often described as a Poisson or over-dispersed Poisson distribution. The formula for a Poisson distribution is:

$$P \langle n | \mu \rangle = \frac{e^{-\mu} \cdot \mu^n}{n!}$$

$P(n|\mu)$ is the probability of observing n events in some time interval, when the expected number of events in that time interval is μ . For this analysis, μ is the estimated strike rate (1.32 for Navy; 1.31 for Coast Guard) over the next 7-year period from late 2025 through late 2032.

From the 7-year Navy strike rate (1.32), the Poisson distribution estimates the probability of n where $n=0$ (no strikes), 1 strike, 2 strikes, and 3 strikes over the next 7-year period (i.e., late 2025 through late 2032) as follows:

- $P(n=0) = 0.267$ or a 27% chance of zero strikes
- $P(n>0) = 0.733$ or a 73% chance of more than zero strikes
- $P(1) = 0.353$ or a 35% chance of 1 strike
- $P(n>1) = 0.380$ or a 38% chance of more than 1 strike
- $P(2) = 0.233$ or a 23% chance of 2 strikes
- $P(n>2) = 0.148$ or a 15% chance of more than 2 strikes

- $P(3) = 0.102$ or a 10% chance of 3 strikes
- $P(n>3) = 0.045$ or a 5% chance of more than 3 strikes
- $P(4) = 0.034$ or a 3% chance of 4 strikes
- $P(n>4) = 0.011$ or a 1% chance of more than 4 strikes

From the 7-year Coast Guard strike rate (1.31), the Poisson distribution estimates the probability of n where $n=0$ (no strikes), 1 strike, 2 strikes, and 3 strikes over the 7-year period as follows:

- $P(n=0) = 0.270$ or a 27% chance of zero strikes
- $P(n>0) = 0.730$ or a 73% chance of more than zero strikes
- $P(1) = 0.353$ or a 35% chance of 1 strike
- $P(n>1) = 0.377$ or a 38% chance of more than 1 strike
- $P(2) = 0.232$ or a 23% chance of 2 strikes
- $P(n>2) = 0.145$ or a 15% chance of more than 2 strikes
- $P(3) = 0.101$ or a 10% chance of 3 strikes
- $P(n>3) = 0.044$ or a 4% chance of more than 3 strikes
- $P(4) = 0.033$ or a 3% chance of 4 strikes
- $P(n>4) = 0.011$ or a 1% chance of more than 4 strikes

Based on the resulting probabilities presented in the analysis above, there is an estimated 15% chance that the proposed action would result in more than two large whale vessel strikes by Navy vessels over the next 7-year period. There is also estimated 15% chance that the proposed action would result in more than two large whale vessel strikes by Coast Guard vessels over the next 7-year period. Therefore, we anticipate that the Navy and the Coast Guard could each strike up to three large whales incidental to AFTT activities within the action area over the course of the next 7-year period (i.e., late-2023 through late-2025). The probability of Navy or Coast Guard vessels striking more than three large whales over this period is very low (i.e., less than 5%) and, therefore, considered unlikely to occur.

From our vessel strike probability analysis above, we estimate that the proposed action would result in up to three large whale Navy vessel strikes and up to three large whale Coast Guard vessel strikes from late 2025 through late 2032, which represents the 7-year MMPA permit period for AFTT Phase IV. These estimates include both ESA-listed and non-ESA-listed species. As previously noted, for our effects analysis we assume that AFTT activities by the Action Proponents during the Permits Division's proposed incidental take authorization pursuant to the MMPA will continue into the reasonably foreseeable future at levels similar to those assessed in this opinion. Therefore, in addition to the calculations above for the 7-year MMPA permit period, we anticipate that military readiness activities in the AFTT action area will result in up to three large whale Navy vessel strikes and up to three large whale Coast Guard vessel strikes every seven years into the reasonably foreseeable future.

Next, we consider the likelihood of an Action Proponent vessel strike of each particular species of ESA-listed large whale within the AFTT action area. Many reported whale strikes are not identified to the species level, which increases the difficulty in predicting which species of large whales are most likely to be struck during future training and testing activities. To inform our analysis of the likelihood of striking any particular species, we compiled information on detected annual rates of large whale mortality and serious injury (M/SI) from all vessel strikes (i.e. military and non-military) recorded in the Atlantic Ocean and Gulf of America from 2017-2021 (unless otherwise noted) based on information from the latest NMFS SARs. We recognize that not all commercial vessel strikes are documented or reported (e.g., See Rockwood et al. 2017), so not all instances of serious injury and mortality are represented in the annual rates reported in the SARs. However, the annual rates of large whale serious injury and mortality from vessel collisions in the SARs do provide a reasonable science-based representation of the relative susceptibility of different large whale species to vessel strike in the action area. To calculate estimates for the relative likelihood of striking each species, we summed the annual rates of M/SI, then divided each species' annual rate by this sum (Table 62). Because some of the unidentified whales struck by Action Proponent vessels in previous years could have been non-ESA-listed large whales species (or DPSs) and future strikes could involve non-listed species, we include non-ESA-listed large whales in this calculation. As shown in Table 62, based on the most recent information in the available SARs, 71.3% of the M/SI large whale vessel strikes in the Atlantic and Gulf of America region involved species that are not listed under the ESA (i.e., humpback West Indies DPS and minke whales). Our vessel strike probability analysis above estimated that the proposed action would result in up to three large whale Navy vessel strikes and up to three large whale Coast Guard vessel strikes over seven years. However, based on the M/SI species probabilities, if the Navy or Coast Guard were to strike three large whales, it is highly unlikely that all three would be ESA-listed species. The likelihood that all three strikes would be an ESA-listed species is about 5% (i.e., calculated as the likelihood that one strike would be an ESA-listed species, or 0.37, cubed). The likelihood that two out of three strikes would be an ESA-listed species is about 14% (i.e., calculated as the likelihood that one strike would be an ESA-listed species, or 0.37, squared). Therefore, after adjusting our vessel strike probability analysis for non-listed species, we estimate that the proposed action will result in up to two ESA-listed large whale Navy vessel strikes and up to two ESA-listed large whale Coast Guard vessel strikes over the AFTT Phase IV 7-year period (and each 7-year period in to the reasonably foreseeable future).

The vessel strike probability analysis using the Poisson distribution described above concluded that there was a 27% chance that zero whales would be struck by Navy vessels and a 27% chance that zero whales would be struck by Coast Guard vessels over the next seven years, indicating a 73% chance that at least one whale would be struck over the next seven years (for both Navy and Coast Guard). To estimate the percent likelihood of striking a particular species of large whale once over seven years (column 4 in Table 62), we multiplied the relative likelihood of striking each species (column 3 in Table 62) by the total probability of striking a whale (i.e., 73%). To

calculate the percent likelihood of striking a particular species of large whale twice over seven years (column 5 in Table 62, we squared the value estimated for the probability of striking a particular species of whale once (i.e., to calculate the probability of an event occurring twice, multiply the probability of the first event by the probability of the second event). Likewise, to calculate the percent likelihood of striking a particular species of large whale three times over seven years (column 6 in Table 62), we cubed the value estimated for the probability of striking a particular species of whale once.

Table 62. Annual Rates of M/SI for Large Whale Species (or DPSs) from Vessel Strikes in the Atlantic Ocean and Gulf of America from 2017 to 2021 (unless otherwise noted), and Relative Probability of Striking each Large Whale Species or DPS During that Time Period (Hayes et al. 2023)

Species / DPS	Annual rate of M/SI from vessel strike	Percent of total M/SI (all species)	Percent Likelihood of One Strike Over 7 Years	Percent Likelihood of Two Strikes Over 7 Years	Percent Likelihood of Three Strikes Over 7 Years
Blue whale	0.0	0.0%	0.0%	0.0%	0.0%
Fin whale	0.6	8.2%	6.0%	0.4%	< 0.1%
Sperm whale	0.0 ^a	0.0%	0.0%	0.0%	0.0%
Sei whale	0.0 ^b	0.0%	0.0%	0.0%	0.0%
North Atlantic right whale ^c	1.5	20.5%	15.0%	2.3%	0.1%
Rice's whale	0.0	0.0%	0.0%	0.0%	0.0%
Humpback whale West Indies DPS (non-ESA-listed) ^d	4.4 ^a	60.3%	44.0%	19.4%	3.8%
Minke whale (non-ESA-listed)	0.8	11.0%	8.0%	0.6%	0.1%
Total for all species/DPSs combined	7.3	100%			

^a Based on data from 2013 to 2017 (Hayes et al. 2020).

^b Although there were no confirmed sei whale M/SI incidents linked to vessel strike, for 4 (out of 7) M/SI incidents from 2016 to 2020 the cause of death could not be determined (Garron et al. 2022).

^c MSI based on 2018 to 2022 SAR data (Hayes et al. 2024)

^d MSI based on 2019 SAR data for only the Gulf of Maine humpback whale stock, which is a part of the West Indies DPS (Hayes et al. 2020).

Based solely on the M/SI species probabilities presented in Table 62, for both Navy and Coast Guard vessels, there is a greater than zero probability of striking the following species: West Indies DPS humpback whale, minke whale, fin whale, and North Atlantic right whale. Of these, only the fin whale and North Atlantic right whale are ESA-listed. Also, based on the M/SI species probabilities, a zero vessel strike probability was calculated for the following ESA-listed species based on the fact that no vessel strikes (i.e., by any vessels) have been reported in the Atlantic or Gulf of America for these species in recent years: blue whale, sperm whale, sei whale, and Rice's whale.

While the M/SI species probabilities presented in Table 62 are a good starting point for assessing relative risk of vessel strike to particular species, they do not account for other important factors specific to the proposed action that could either decrease or increase this risk for a particular species. These include: 1) mitigation measures specifically designed to reduce vessel strike risk to particular species; 2) the relative distribution of Action Proponent vessel traffic (particularly large vessels) in relation to the distribution and density of particular large whale species; and 3) the long-term history (i.e., beyond the years used to calculate M/SI) of Action Proponent vessel strikes involving particular species for instances where a species identification was made. While it is not possible to incorporate these factors into our quantitative analysis above, we consider these factors qualitatively as part of our overall large whale vessel strike exposure analysis.

The Rice's whale is the only ESA-listed large whale species with a known range exclusively in the Gulf of America. Based on the recent history of military vessel strikes, and the relative distribution of vessel activity within the AFTT action area, if the Navy or Coast Guard were to strike an ESA-listed large whale there is a very high probability that this would occur within the Atlantic Ocean. As noted above, the last six military vessel strikes involving large whales (dating back to 2009) have all occurred within the Atlantic portion of the action area, and there has not been a documented Navy or Coast Guard vessel strike (of any species) in the Gulf of America portion of action area since 2001 (Cowan 2024). In addition, the Action Proponents conduct a relatively low level of training and testing activities in the Gulf of America, resulting in far fewer vessel at-sea days in areas where this species occurs compared to other portions of the action area. Based on historical information we expect only about 2% of Navy vessel activity and 16% of Coast Guard vessel activity associated with AFTT activities to occur within the Gulf of America. The Action Proponents have also proposed geographic mitigation measures to avoid conducting most activities in the Rice's whale core use area, further reducing the likelihood of a vessel strike of this species. Action Proponent vessel activity throughout much of the Rice's whale core use mitigation area is relatively low compared to other higher use areas (e.g., Corpus Christi OPAREA) within the Gulf of America. The exception to this may be the overlap between

the Pensacola and Panama City OPAREAs and the northern portion of the Rice's whale core use mitigation area. The standard activity-based mitigation measures for vessels described in Section 2.3.2 may further reduce the risk of a Rice's whale strike. While vessel strike poses a threat to Rice's whales (Soldevilla et al. 2017), no instances of military or non-military vessel strike involving this species have been observed or documented since 2009. Rice's whale vessel strikes, in general, are expected to be relatively rare given the species' extremely small population size. While it is also possible that commercial vessel strikes of this species have occurred in recent years but have not been reported or documented (due to a low stranding probability), the Action Proponents are required to report all vessel strikes. There has never been a reported Rice's (or Gulf of Mexico Bryde's, as this species was previously known) whale vessel strike by a Navy or Coast Guard vessel. After considering the factors above, we find it extremely unlikely that a Rice's whale vessel strike will occur as a result of the proposed action, thus, the potential effects of vessel strike on this species are discountable.

As discussed in Sections 4.2.1 (North Atlantic Right Whale) and 5.11.1, vessel strike remains a serious threat to the North Atlantic right whale population and is one of the leading causes of injury and mortality in the ongoing Unusual Mortality Event (UME) for this species. This species is particularly susceptible to vessel strikes because they spend between 67% to 98% of their time in the upper 10 m of the water column throughout much of their range (Garrison et al. 2022). Based solely on the M/SI vessel strike proportions by species (Table 62), North Atlantic right whales have the second highest probability of being struck by a vessel of all large whale species in the action area. Of the six vessel strikes by Action Proponent vessels in the action area since 2009, two were confirmed to be North Atlantic right whales (Coast Guard 2009) and three others were not identified by species. Based on information provided by the Navy, we cannot rule out the possibility that one or more of the three unidentified Navy strikes in the action area since 2009 could also have involved a North Atlantic right whale.

Starting in 2012, NMFS and the Navy have worked collaboratively to develop mitigation measures specifically aimed at minimizing the risk of a North Atlantic right whale vessel strike. Vessel strike mitigation measures were added during the 2013 AFTT Phase II consultation, and additional measures were added in 2018 for Phase III. All of the North Atlantic right whale vessel strike mitigation measures from Phase III have been carried over to the Action Proponents' Phase IV proposed action. In addition to the standard activity-based mitigation for vessels described in Section 2.3.2, the Action Proponents have proposed vessel strike mitigation measures in geographic mitigation areas and during times of year to minimize the risk of a North Atlantic right whale vessel strike. These include: vessel speed restrictions during specified activities or based on right whale sightings information obtained through the North Atlantic Right Whale Sighting Advisory and Early Warning Systems, as well as WhaleMap; the use of real-time (or near real-time) sightings information for event planning and Lookout awareness; minimizing vessel transits in the Southeastern right whale calving critical habitat, to the maximum extent practical; and avoiding high-speed propulsion testing events in feeding and

calving areas where right whales are known to congregate. See Vessel Strike Mitigation Measures in this section above, and Section 2.3.2 North Atlantic Right Whale Mitigation Areas for details. Implementation of these measures is expected to significantly reduce the probability of a North Atlantic right whale vessel strike as a result of the proposed action. No North Atlantic Right Whale vessel strikes have been reported by the Action Proponents in the AFTT action area since these vessel strike mitigation measures went into effect. Only one vessel strike was reported since 2013 (Coast Guard strike in 2024), and although not identified by species, based on the available information it is likely that this strike was of a humpback whale, not a right whale. Given the extensive mitigation measures in place to avoid striking a North Atlantic right whale, and that a vessel strike of this species has not been reported by a Navy or Coast Guard vessel in at least 12 years, it is extremely unlikely that a North Atlantic right whale vessel strike will occur as a result of the proposed action. Therefore, the potential effects of vessel strike on this species are discountable.

Reported or documented instances of vessel strikes involving Western North Atlantic blue whales are extremely rare. We reviewed the NMFS Northeast Fisheries Science Center *Serious injury and mortality determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces* reports²⁴ covering the years 1999 to 2021 and did not find a single Western North Atlantic blue whale mortality or serious injury due to vessel strike. Blue whale densities are expected to be very low in the areas where vessel traffic (military and non-military) is greatest along the Atlantic coast. Military vessel activity accounts for only about 1% of all vessel traffic, and we have no information indicating that a Navy or Coast Guard vessel has struck a blue whale in the AFTT action area in the past. Therefore, we find it extremely unlikely that a blue whale vessel strike will occur as a result of the proposed action, thus, the potential effects of vessel strike on this species are discountable.

Whereas blue whale vessel strikes are extremely rare, based on the NMFS M/SI reports from 1999 to 2021, fin whale vessel strikes are a more common occurrence in the action area. From 1999 to 2021 there have been 26 confirmed fin whale vessel strikes along the U.S. East Coast, based on the serious injury and mortality reports noted above. These data indicate that fin whales are one of the most commonly struck large whales in the Mid-Atlantic and Northeast portions of the action area. Sei whale vessel strikes in the North Atlantic appear to be less common as compared to fin whale strikes. As shown in Table 62, the vessel strike M/SI for this species is zero in the most recent SAR 5-year period. However, as noted above, for several sei whale strandings during this time period (i.e., 2017 through 2021) the cause of death was not determined (Garron et al. 2022). In addition, sei whale vessel strike M/SI reports for the U.S. East Coast were a more common occurrence in previous SAR 5-year periods (i.e., four from 2012 to 2016; three from 2007 to 2011; and two from 2002 to 2006). Therefore, while our M/SI

²⁴ All reports are available from NOAA Fisheries online at: <https://www.fisheries.noaa.gov/resource/publication-database/marine-mammal-mortality-and-serious-injury-reports>

vessel strike probability analysis above (Table 62) suggests the likelihood of striking a fin (6.0%) or sei whale (0.0%) is relatively low, the longer-term M/SI time series data suggest that our analysis (based on 2017 through 2021 data) may underestimate the future risk of vessel strike to these species.

Fin whales are common in waters of the U.S. Atlantic EEZ, principally from Cape Hatteras northward, and have been sighted in every season throughout much of the U.S. EEZ north of 30° N (Hayes et al. 2023). The southern portion of the sei whale Nova Scotia stock's range during spring and summer includes the northern portions of the U.S. Atlantic EEZ—the Gulf of Maine and Georges Bank. Feeding areas for both fin and sei whales have been identified as key habitats that seasonally overlap with portions of the AFTT Northeast Range Complex (LaBrecque et al. 2015). New England and Gulf of St. Lawrence waters represent major feeding ground for fin whales. Zoidis et al (2021) reported the highest sighting rate for fin whales in the New York Bight region in the summer (3.44 whales/1,000 km). Spring is the period of greatest sei whale abundance in U.S. Atlantic waters, with sightings concentrated along the eastern margin of Georges Bank, into the Northeast Channel area, south of Nantucket, and along the southwestern edge of Georges Bank (Hayes et al. 2023). Persistent year-round detections in Southern New England and the New York Bight highlight this as an important region for sei whales (Hayes et al. 2023). Military readiness activities that involve vessel movements in the Northeast Range Complex could occur year-round, however, any potential overlap with feeding activities in these BIAs would be seasonal. Both fin and sei whales could also be susceptible to vessel strike in other portions of the action area during seasonal migrations. Based on our evaluation of the long-term M/SI vessel strike data and the overlap between fin and sei whale occurrence and AFTT military readiness activities in the Northeast Atlantic portion of the action area (including feeding BIAs), we find that it is reasonably likely that one fin whale strike and one sei whale strike could occur over the 7-year period of the proposed MMPA rule (and each 7-year period in to the reasonably foreseeable future).

Reported or documented instances of vessel strikes involving sperm whales in the AFTT action area are rare. Sperm whale densities are expected to be very low in the areas where vessel traffic (military and non-military) is greatest along the Atlantic coast and Gulf of America. Historically, one probable sperm whale mortality due to a vessel strike was documented for the Gulf of America in 1990 in the vicinity of Grande Isle, Louisiana (Jensen and Silber 2003). The last documented sperm whale vessel strike stranding mortality on the Atlantic coast was in 2012 off Florida (Hayes et al. 2020). In 2006 a sperm whale was found dead from ship-strike wounds off Portland, Maine (Hayes et al. 2020). The previous two documented strikes were in May 2000, when a merchant ship reported a sperm whale vessel strike in Block Canyon (east of New Jersey and south of Rhode Island), and in May 1994 when a ship-struck sperm whale was observed south of Nova Scotia, Canada (Reeves and Whitehead 1997).

While the probability of any vessel (military or non-military) striking a sperm whale within the action area is relatively low, there are two documented instances (one confirmed species, the

other probable) of a Navy vessel strike involving a sperm whale within the AFTT action area since 2001. In June 2001 a Navy Destroyer struck a sperm whale 20 miles south of Puerto Rico (Jensen and Silber 2003); in May 2005 a Navy Amphibious Assault Ship reported striking a marine mammal in the VACAPES Range Complex which, based on the Chief Mate's report and the depth regime where the strike occurred, was presumed to be a sperm whale (Busch 2018). Although a sperm whale strike by a Navy or Coast Guard vessel has not occurred since 2005, the two Navy strikes in the past 24 years suggest that it is reasonably likely that one sperm whale strike could occur over the 7-year period of the proposed MMPA rule.

Our vessel strike exposure analysis was based on the results of our vessel strike probability calculations in combination with supplemental information including an evaluation of vessel strike risk factors, recent military and non-military vessel strike history in the action area, and species-specific biological and life history information. In summary, we anticipate the following number and species of large whale vessel strikes as a result of the proposed action:

- Up to two ESA-listed large whale strikes by Navy vessels over the 7-year MMPA permit period (i.e., late-2025 through late-2032), and over every seven years of the proposed action into the reasonably foreseeable future. This total of two whales can include any combination of up to one fin whale, up to one sei whale, and up to one sperm whale.
- Up to two ESA-listed large whale strikes by Coast Guard vessels over the 7-year MMPA permit period (i.e., late-2025 through late-2032), and over every seven years of the proposed action into the reasonably foreseeable future. This total of two whales can include any combination of up to one fin whale, up to one sei whale, and up to one sperm whale.

The available information does not allow for a detailed analysis of the sexes or life stages of large whales that we would expect to be struck by vessels as a result of the action. Based on strandings data reports, we assume that for all affected ESA-listed species (i.e., fin whales, sei whales, and sperm whales) vessel strikes could include a combination of both males and females, and any of the following life stages: adults, subadults, juveniles, yearlings, and calves.

Response Analysis

Vessel collisions with large whales can result in death or serious injury of the animal. Wounds resulting from ship strike may include massive trauma, hemorrhaging, broken bones, or propeller lacerations (Knowlton and Kraus 2001). Superficial strikes may not kill or result in the death of the animal. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Vanderlaan and Taggart 2007). Higher speeds during collisions result in greater force of impact and also appear to increase the chance of severe injuries or death (Silber et al. 2010; Gende et al. 2011).

An examination of all known ship strikes from all shipping sources (non-military and military) indicates vessel speed is a principal factor in whether a vessel strike results in death or serious injury (Knowlton and Kraus 2001; Laist et al. 2001; Pace and Silber 2005; Vanderlaan and

Taggart 2007). Laist et al. (2001) found that most large whale deaths from vessel strike occurred when a vessel was traveling in excess of 13 knots. Jensen and Silber (2003) detailed 292 records of known or probable ship strikes (inclusive of military and non-military vessels) of all large whale species from 1975 to 2002. Of these, vessel speed at the time of collision was reported for 58 cases. Of these cases, 39 (or 67%) resulted in serious injury or death. Operating speeds of vessels that struck various species of large whales ranged from 2 to 51 knots. The majority (79%) of these strikes occurred at speeds of 13 knots or greater. The average speed that resulted in serious injury or death was 18.6 knots. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 to 75% as vessel speed increased from 10 to 14 knots, and exceeded 90% at 17 knots. While modeling studies have suggested that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Knowlton et al. 1995; Clyne et al. 1999), this is inconsistent with Silber et al. (2010), which demonstrated that there is no such relationship (*i.e.*, hydrodynamic forces are independent of speed).

In another study, Vanderlaan and Taggart (2007) analyzed the probability of lethal mortality of large whales at a given speed, showing that the greatest rate of change in the probability of a lethal injury to a large whale as a function of vessel speed occurs between 8.6 and 15 knots. The chances of a lethal injury decline from approximately 80% at 15 knots to approximately 20% at 8.6 knots. At speeds below 11.8 knots, the chances of lethal injury drop below 50%, while the probability asymptotically increases toward 100% above 15 knots.

Vessel size also plays a role in the anticipated outcome when a large whale vessel strike occurs. Kelley et al. (2021) found that while vessels of all sizes can cause lethal injuries to whales, large vessels (>20 m) produce much larger stresses even when travelling at reduced speeds (*i.e.*, 10 knots). Garrison et al. (2024a) developed a model characterizing the probability that a whale-vessel interaction will be lethal to the whale as a function of vessel speed and length. They found that decreasing vessel speeds reduced the likelihood of a lethal outcome for all vessel size classes, but this effect was strongest for vessels less than 350 ft in length. Their model predicted that probability a strike by a vessel greater than 350 ft will be lethal exceeded 80% at all speeds above five knots (Garrison et al. 2024a).

Our exposure analysis considered vessel strike of marine mammals comprehensively, as a result of all Action Proponent vessel movement within the action area, as opposed to in the context of specific training or testing exercises. For this reason, we are not able to predict the speed or size of Navy or Coast Guard vessels that are expected to result in ship strikes of large whales. Because of these unknowns, we assume that all incidents of ESA-listed large whale vessel strike associated with AFTT activities in the action area will result in mortality or serious injury leading to mortality. We consider this a reasonable assumption given the anticipated vessel sizes and speeds of AFTT Action Proponent vessels in areas that overlap with where ESA-listed large whales are known to occur.

6.2 Sea Turtles

This section addresses the effects of acoustic (i.e., from sonar and other transducers, and air guns), explosive, and vessel strike stressors on ESA-listed sea turtles from the proposed AFTT activities. We start with an overview of the methodology for the Navy's quantitative analysis of the effects of these stressors on sea turtles.

6.2.1 Acoustic and Explosive Effects Analysis

To evaluate the impacts from acoustic stressors associated with proposed training and testing activities, the Navy performed a quantitative analysis to estimate the number of instances (i.e., exposures) that could affect ESA-listed sea turtles and the magnitude of that effect (e.g., injury, hearing loss, behavioral response). Similar to that described above for marine mammals (Section 6.1.1), the quantitative analysis utilizes NAEMO, and takes into account criteria and thresholds used to predict impacts in conjunction with spatial densities of sea turtles within the action area. One important difference from the quantitative analysis for marine mammals is that avoidance is not factored into NAEMO impacts estimates for sea turtles (i.e., sea turtle are assumed not to have the ability to avoid acoustic impacts by swimming away from a sound source).

NAEMO was used to estimate impacts from acoustic and explosive stressors for all ESA-listed sea turtles in the action area except hawksbills. Hawksbill turtles are not frequently observed during surveys conducted within the AFTT action area, and are generally limited with the action area to south Florida. Due to the lack of hawksbill sightings in survey data, impacts for hawksbill sea turtles were not estimated quantitatively with NAEMO.

We consider the modeling conclusions from the Navy's analysis to represent the best available data on exposure of ESA-listed sea turtles to acoustic and explosive stressors from the proposed action. We also find that the estimates of take resulting from this analysis are reasonably certain to occur. Although not incorporated into NAEMO, activity-based mitigation measures (described in Section 2.3.2, Table 5, 6, and 7) may further reduce the number and severity of sea turtle exposures to AFTT acoustic and explosive stressors. In addition, mitigation requirements in the Nearshore North Carolina Sandbar Shark and Sea Turtle Mitigation Area, Panama City Gulf Sturgeon and Sea Turtle Mitigation Area, and Inshore Manatee and Sea Turtle Mitigation Area (Section 2.3.2, Table 13, 14, and 15) are designed to further minimize impacts of explosives on ESA-listed sea turtles.

For more details on this approach see Section 6.1.1 above, or the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase IV Training* (Navy 2024h).

Density Estimates

The density data used in the NAEMO quantitative impact analysis for each ESA-listed sea turtle species present in the AFTT action area is described in the Navy's density technical report (Navy 2024j). For most sea turtle species, abundance is estimated using line-transect surveys, or mark-recapture studies. Sea turtle abundance estimates have also been derived from other in-water

survey data in selected areas that rely on published abundance and distribution data from nesting sites (Garrison et al. 2019). For Phase IV, new sea turtle density models were developed by DiMatteo et al. (2024) for the East Coast stratum, and by the SEFSC for the Gulf of America stratum as part of the Gulf of Mexico Marine Assessment Program for Protected Species (Garrison et al. 2023b; Rappucci et al. 2023). As discussed above for marine mammals, the Navy compiled the best available information on sea turtle species' densities in the action area into the NMSDD, which was used in NAEMO for estimating impacts to sea turtles from acoustic and explosive stressors.

The sea turtle density data used by the Navy to quantitatively assess impacts is primarily from NMFS's aerial surveys with supplemental data from shipboard surveys from NMFS and others. NAEMO outputs only represent estimates for larger sea turtles, since smaller turtles (i.e., including most less than about 30 cm diameter, and some proportion between 30 and 40 cm), are likely missed from aerial survey. For these reasons, neither age class nor size are explicitly accounted for in the sea turtle density data, although the larger size makes sightability and identification of age and species easier.

The density spatial model in the Gulf of America was limited to the shelf break where most sea turtle sightings occur. For AFTT Phase III an extrapolation of sea turtle densities was made out to the U.S. EEZ to cover portions of Navy OPAREAs that occur off the shelf break. For Phase IV, sea turtle densities were not estimated off the shelf break as this portion of the action area was not modeled in NAEMO. Although this likely results in an underestimation of acoustic impacts, the anticipated number of exposures to acoustic effects in the Gulf of America off the shelf break is likely very small, given the expected low sea turtle densities and relatively low level of AFTT activities involving sonar or explosives in this portion of the action area.

Criteria and Thresholds to Predict Impacts

The Navy's quantitative acoustic effects analysis for sea turtles relies on information about the numerical sound and energy values that are likely to elicit certain types of physiological and behavioral reactions. The following section describes the specific sea turtle criteria and thresholds developed and applied for each sound source associated with the proposed AFTT activities. A detailed description of the sea turtle criteria and threshold development is included in the Navy's technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase IV)* (Navy 2024e).

Non-auditory Injury and Mortality

The Navy's quantitative analysis assessed the potential for AFTT activities involving in-water explosives to physically injure or kill ESA-listed sea turtles. The criteria and thresholds for non-auditory injury and mortality in sea turtles are the same as those described for marine mammals in Section 6.1.1.

Auditory Impacts

Although no studies have directly measured underwater TTS in ESA-listed sea turtles, two recent studies examined underwater TTS in freshwater turtles. Salas et al. (2023a) exposed red-eared sliders (*Trachemys scripta elegans*) to SPLs between 155 and 193 dB re 1 μPa^2 s, and auditory sensitivity was measured at 400 Hz using auditory evoked potential methods. The mean predicted TTS onset was 160 dB re 1 μPa^2 s and there were significant positive relationships between shift magnitude and exposure duration, amplitude, and SEL. The SELs at which TTS was observed in these freshwater turtle studies are considerably lower than the predicted threshold of 200 dB re 1 μPa^2 s for ESA-listed sea turtles (Salas et al. 2023a), which was based on surrogate TTS data from freshwater fishes (U.S. Department of the Navy 2017). In a similar study using Eastern painted turtles, Salas et al. (2023b) reported similar results, with TTS onset occurring at much lower SELs than previously predicted.

Although sea turtles appear to be slightly less sensitive to sound (e.g., higher thresholds at some frequencies) than freshwater turtles (Piniak et al. 2016), Salas et al. (2023a) conclude that their findings “warrant caution and awareness” that ESA-listed sea turtles may incur hearing loss at lower sound levels than previously thought.

New criteria and thresholds for the onset of sea turtle TTS and AINJ were developed for Phase IV based on the best available data (Table 63).

Table 63. Comparison of Phase III and Phase IV Sea Turtle TTS and AINJ Onset Levels for Non-impulsive (sonar) and Impulsive (explosives, airguns) Sound Sources (weighted SEL onset units are dB re 1 μPa^2 s; impulsive peak SPL onsets units are dB re 1 μPa)

Source Type and Metric	Phase 3		Phase 4	
	TTS	AINJ (PTS ²)	TTS	AINJ (PTS)
Non-impulsive onset SEL (weighted) ¹	200	220	178	198
Impulsive onset SEL (weighted)	189	204	169	184
Impulsive onset Peak SPL	226	232	224	230

¹The weighted non-impulsive thresholds by themselves only indicate the TTS/AINJ threshold at the most susceptible frequency.

² Auditory injury (AINJ) was previously referred to as permanent threshold shift (PTS). The new terminology acknowledges that auditory injury may occur without PTS.

A new sea turtle composite audiogram was derived from existing hearing data (Figure 60). Based on the composite audiogram and TTS data from freshwater turtles, exposure functions were created for non-impulsive noise sources (Figure 61).

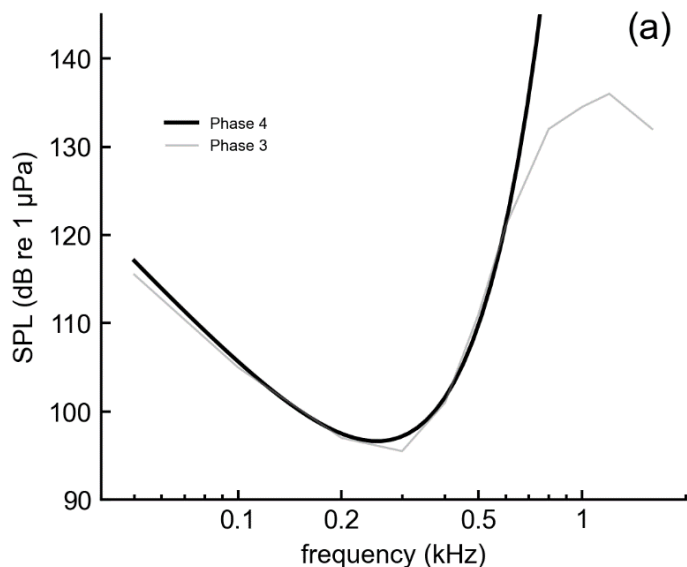


Figure 60. Comparison of Phase III (thin gray lines) and Phase IV (thick black lines) Sea Turtle Composite Audiograms (Navy 2025c)

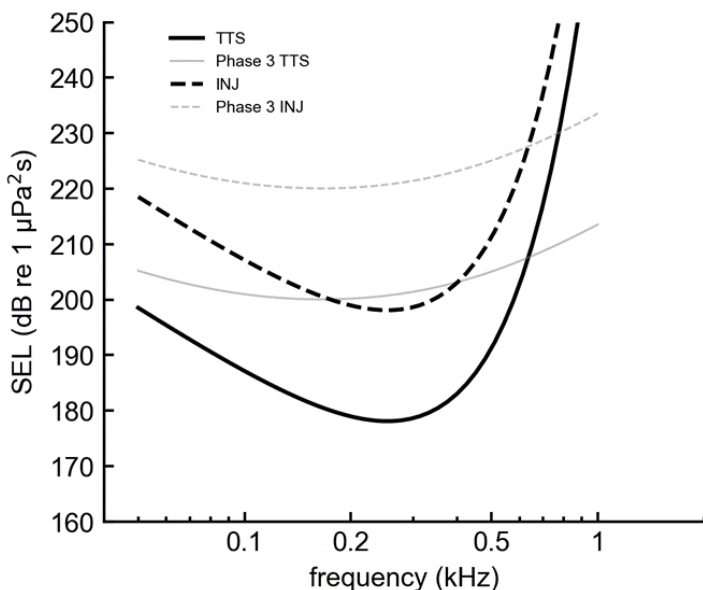


Figure 61. Comparison of Phase III (thin gray lines) and Phase IV (thick black lines) Sea Turtle Exposure Functions for Non-impulsive TTS (solid lines) and AINJ (dashed lines) (Navy 2025c)

Behavioral Response

The unweighted SPL rms behavioral disturbance threshold of 175 dB for sonar (below 2 kHz), and airguns were carried over from Phase III for the NAEMO Phase IV analysis. For sea turtle exposures to multiple explosions a threshold of 164 dB re 1 $\mu\text{Pa}^2\text{s}$ SEL was used. For a single explosion the behavioral response threshold is set to the impulsive TTS onset threshold of 169 dB re 1 $\mu\text{Pa}^2\text{s}$ SEL.

Ranges to Effects

Ranges to effects to sea turtles from exposure to sonar and other transducers, airguns, and explosives are provided in the AFTT Final Supplemental EIS/OEIS: *Appendix E. Acoustic and Explosive Impacts Analysis for Marine Mammals, Reptiles, and Fishes in the Atlantic Fleet Training and Testing Study Area* (Navy 2025b), and are incorporated into this opinion by reference (Section 3.5, pp. 3-225 through 3-232). For a more detailed discussion of ranges to effects, in general, see Section 6.1.1 above or the AFTT Phase IV BA (Navy 2024c).

Exposure Analysis

Section 6.2.1 presented information on the criteria and thresholds used to estimate impacts to ESA-listed sea turtles from acoustic and explosive stressors. Additional information on these criteria is described in the Navy's criteria and thresholds technical report (Navy 2024e). This section presents information on the estimated number of exposures of ESA-listed sea turtles to acoustic (i.e., sonar and other transducers, and air guns) and explosive stressors that are expected to result in a significant behavioral response, TTS, AINJ, non-auditory injury, or mortality. Exposure estimates were produced using the NAEMO approach as described in Section 6.1.1, and in the Navy's technical report (Navy 2024h). For each sea turtle species, a multi-sectioned table quantifies impacts as follows:

- The first section shows the number of instances of each effect type that could occur due to each substressor (sonar, air guns, or explosives) over a maximum year of activity. Impacts are shown by type of activities (Navy training, Coast Guard training, or Navy testing activities).
- The second section shows the percent of total impacts that would occur within seasons and the following general geographic areas: Northeast (Atlantic waters north of New Jersey); Mid-Atlantic (Atlantic waters from New Jersey to North Carolina); Southeast (Atlantic waters from South Carolina to Florida); Key West (areas around the southernmost portion of Florida); Gulf of America; and High Seas (areas of the Atlantic east of the range complexes, generally outside of the U.S. EEZ).
- The third section shows which activities are most impactful to the species. Activities that cause 5% or more of total impacts to a species are shown here.
- The fourth section shows impacts in critical habitats where they are designated for ESA-listed sea turtles.

As discussed above, NAEMO outputs only represent estimates for larger sea turtles since density estimates are largely derived from aerial surveys, which typically can only detect the larger sea turtles (Epperly et al. 1995). Turtles smaller than about 40 cm diameter are likely being missed by aerial surveys (regardless of altitude) to an unknown degree and represent a sizable proportion of the population of all sea turtle species (DiMatteo et al. 2024). As such, NAEMO estimates, based on these sea turtle density models, underestimate impacts to an unknown extent.

Since data are not available to estimate the proportion of smaller sea turtle size classes that are missed, we cannot quantify impacts to smaller sea turtles at this time. Since we cannot quantify

impacts to smaller sea turtles (i.e., less than 40 cm diameter) from sonar, air guns and explosives, we instead use a surrogate based on: 1) the ranges to effects, which are the distances in the water column that correlate with each of the predicted effects (e.g., significant behavioral response, TTS, AINJ, non-auditory injury, and mortality) from sonar and explosives in those areas occupied by sea turtles less than 40 cm diameter, and 2) sonar and explosive activity levels, which is the total number of hours or count (by sonar or explosive bin type) that would be used in the action area as part of the proposed action.

During the early life histories of sea turtles, hatchlings and juveniles spend a majority of time passively floating in prevailing ocean currents and inhabiting floating vegetation mats (i.e., Sargassum). The Action Proponents have proposed mitigation measures to minimize impacts on floating vegetation used by hatchling and juvenile sea turtles. Although the density data does not quantitatively allow the separation of sea turtle size classes, the effects to small sea turtles (less than 40 cm diameter) is somewhat minimized through mitigation.

Green Sea Turtle – North Atlantic DPS

Estimated exposures resulting in adverse effects to North Atlantic DPS green sea turtles from the use of sonar, air guns, and explosives as part of the proposed action are shown in Table 64. The largest contributor of impacts from sonar (in order of level of impacts) are due to Acoustic and Oceanographic testing activities in the Southeast during winter, the Mid-Atlantic during fall, the Northeast during fall, and the Gulf of America during spring and summer (Navy 2024a). The largest contributor of impacts from explosives (in order of level of impacts) are due to Bombing Exercise Air-to-Surface training activities in the Mid-Atlantic during fall, the Southeast during winter, and the Gulf of America during fall. Since most explosives proposed for AFTT would occur offshore, we expect the majority of exposures to explosive impacts to affect juvenile green sea turtles in their oceanic phase. Exposures to impacts from sonar, which are expected to occur in both neritic and oceanic green turtle habitats, could impact oceanic-phase juvenile, neritic-phase juvenile, subadult and adult green sea turtles throughout the action area.

Table 64. Estimated Acoustic and Explosive Effects to North Atlantic DPS Green Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Air gun	Navy Testing	-	1	0	-	-
Explosive	Navy Training	2,442	886	21	2	1
Explosive	Navy Testing	910	563	12	(1)	0
Explosive	USCG Training	(1)	(1)	0	-	-
Sonar	Navy Testing	609	6,800	35	-	-
Maximum Annual Total		3,962	8,251	68	3	1
<i>Percent of Total Impacts</i>						
<i>Season</i>	<i>Northeast</i>	<i>Mid-Atlantic</i>		<i>Southeast</i>		
Winter	0%	0%		26%		
Spring	0%	7%		22%		
Summer	1%	7%		3%		
Fall	2%	17%		14%		
<i>Activities with 5% or More of Total Impacts</i>			<i>Category</i>	<i>Percent of Total Impacts</i>		
Acoustic and Oceanographic Research (ONR)			Navy Testing	62%		
Bombing Exercise Air-to-Surface			Navy Training	19%		

Notes: BEH = Significant Behavioral Response; TTS = Temporary Threshold Shift; AINJ = auditory injury; INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts. Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Hawksbill Sea Turtle

Due to the lack of hawksbill sightings in survey data, impacts for hawksbill sea turtles were not estimated quantitatively with NAEMO. Given the limitations in available density data for this species and small spatial overlap with AFTT activities, it is not possible, nor would it be an accurate representation of potential effects, to quantify acoustic impacts (i.e., in the form of the number of turtles suffering mortality, injury, TTS, and behavioral disruption) or to monitor impacts in terms of individual hawksbills affected. Because it is not practical to express the number of hawksbills affected by acoustic impacts, we instead use a surrogate measure based on: 1) the ranges to effects, which are the distances in the water column that correlate with each of the predicted effects (e.g., AINJ, TTS, significant behavioral responses) from sonar and explosives in those areas occupied by the species, and 2) explosive and sonar activity levels, which is the total number of explosives (by bin type) that would be detonated and the total number of sonar hours (by source category) in the action area as part of the proposed action. For details on sea turtle ranges to effects and activity levels, see Section 6.2.1 and Section 2.2, respectively, which reference sections of the AFTT Final Supplemental EIS/OEIS Appendix E. Acoustic and Explosive Analysis Report (Navy 2025b) and the AFTT Phase IV BA (Navy 2024c) where this information can be found.

Since hawksbill turtles are rare north of Florida, any impacts would likely occur in the Gulf or Key West Range Complexes, or the southern portion of the JAX Range Complex. Some hawksbill sea turtles in these areas would likely be exposed to sonar and explosives as part of the proposed action. Given the limited use and proposed locations of activities involving air guns, it is extremely unlikely that hawksbill sea turtles would be exposed to sound from air guns. Given the small spatial overlap between hawksbill occurrence and AFTT activities, we anticipate a relatively small number of annual hawksbill exposures to sonar and explosives will result in adverse effects including AINJ, TTS, significant behavioral response, and associated physiological stress responses. No hawksbill mortalities or non-auditory injuries are anticipated as a result of sonar and explosives due to the anticipated species' density and small spatial overlap (i.e., Gulf of America and south Florida) between the species' range and where most AFTT activities would occur. Hawksbill life stages that could be impacted include adults, subadults and juveniles.

Kemp's Ridley Sea Turtle

Estimated exposures resulting in adverse effects to Kemp's ridley sea turtles from the use of sonar, air guns, and explosives as part of the proposed action are shown in Table 65. Most of the impacts to this species will occur in the Gulf of America portion of the action area during winter and spring. The largest contributor of impacts from sonar are from Acoustic and Oceanographic testing activities; the largest contributors of impacts from explosives are due to Line Charge Testing conducted (Navy 2024a).

Since most explosives proposed for AFTT would occur offshore, we expect the majority of exposures to explosive impacts to affect juvenile Kemp's ridley sea turtles in their oceanic phase. Exposures to impacts from sonar, which are expected to occur in both neritic and oceanic sea turtle habitats, could impact oceanic-phase juvenile, neritic-phase juvenile, subadult and adult Kemp's ridley's throughout the action area.

Table 65. Estimated Acoustic and Explosive Effects to Kemp’s Ridley Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Air gun	Navy Testing	-	(1)	-	-	-
Explosive	Navy Training	789	410	7	(1)	-
Explosive	Navy Testing	5,785	2,448	45	(1)	0
Explosive	USCG Training	10	-	-	-	-
Sonar	Navy Testing	556	6,368	10	-	-
Maximum Annual Total		7,140	9,227	62	2	0
Percent of Total Impacts						
<i>Season</i>	<i>Mid-Atlantic</i>		<i>Southeast</i>		<i>Gulf of America</i>	
Winter	0%		4%		41%	
Spring	0%		4%		26%	
Summer	0%		1%		12%	
Fall	1%		4%		9%	
Activities with 5% or More of Total Impacts				<i>Category</i>	<i>Percent of Total Impacts</i>	
Line Charge Testing				Navy Testing	43%	
Acoustic and Oceanographic Research (ONR)				Navy Testing	31%	
Mine Countermeasure and Neutralization Testing (NAVSEA)				Navy Testing	17%	

Notes: BEH = Significant Behavioral Response; TTS = Temporary Threshold Shift; AINJ = auditory injury; INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Leatherback Sea Turtle

Estimated exposures resulting in adverse effects to leatherback sea turtles from the use of sonar, air guns, and explosives as part of the proposed action are shown in Table 66. The largest contributor of impacts from sonar (in order of level of impacts) are due to Acoustic and Oceanographic testing activities in the Southeast and Northeast during fall, the Mid-Atlantic during summer, and the Gulf of America during spring and winter. Both juvenile and adult leatherbacks are expected to be impacted by AFTT acoustic and explosive stressors occurring in the offshore portions of the action area.

Table 66. Estimated Acoustic and Explosive Effects to Leatherback Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Air gun	Navy Testing	-	0	-	-	-
Explosive	Navy Training	348	191	7	(1)	-
Explosive	Navy Testing	386	1,356	53	1	(1)
Explosive	USCG Training	0	0	0	-	-
Sonar	Navy Training	0	1	-	-	-

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Sonar	Navy Testing	183	2,216	10	-	-
Maximum Annual Total		917	3,764	70	2	1
<i>Percent of Total Impacts</i>						
<i>Season</i>	<i>Northeast</i>	<i>Mid-Atlantic</i>	<i>Southeast</i>	<i>Gulf of America</i>		
Winter	2%	1%	8%	1%		
Spring	1%	1%	11%	1%		
Summer	5%	7%	8%	4%		
Fall	8%	9%	32%	1%		
<i>Activities with 5% or More of Total Impacts</i>				<i>Category</i>	<i>Percent of Total Impacts</i>	
Acoustic and Oceanographic Research (ONR)				Navy Testing	61%	
Small Ship Shock Trial				Navy Testing	9%	
Bombing Exercise Air-to-Surface				Navy Training	8%	
Mine Countermeasure and Neutralization Testing (NAVSEA)				Navy Testing	7%	

Notes: BEH = Significant Behavioral Response; TTS = Temporary Threshold Shift; AINJ = auditory injury; INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Loggerhead Sea Turtle – Northwest Atlantic Ocean DPS

Estimated exposures resulting in adverse effects to Northwest Atlantic Ocean DPS of loggerhead sea turtles from the use of sonar, air guns, and explosives as part of the proposed action are shown in Table 67. The largest contributor of impacts from sonar are due to Acoustic and Oceanographic testing activities primarily in the Southeast and Gulf of America (Navy 2024a). The largest contributors of impacts from explosives (in order of level of impacts) are due to Line Charge testing activities and Bombing Exercise Air-to-Surface training activities in the Southeast during winter, the Mid-Atlantic during fall, and the Gulf of America during winter (Navy 2024a). Since most explosives proposed for AFTT would occur offshore, we expect the majority of exposures to explosive impacts to affect juvenile loggerhead sea turtles in their oceanic phase. Exposures to impacts from sonar, which are expected to occur in both neritic and oceanic loggerhead turtle habitats, could impact oceanic-phase juvenile, neritic-phase juvenile, subadult and adult loggerhead sea turtles throughout the action area.

Table 67. Estimated Acoustic and Explosive Effects to Northwest Atlantic DPS of Loggerhead Sea Turtles over a Maximum Year of Proposed Activities (Navy 2024a)

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Air gun	Navy Testing	-	2	0	-	-
Explosive	Navy Training	11,404	3,330	55	7	2
Explosive	Navy Testing	14,265	7,322	171	2	(1)
Explosive	USCG Training	3	1	(1)	-	-
Sonar	Navy Training	0	(1)	-	-	-
Sonar	Navy Testing	2,335	37,781	189	-	-
Maximum Annual Total		28,007	48,437	416	9	3

<i>Source</i>	<i>Category</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
<i>Percent of Total Impacts</i>						
<i>Season</i>	<i>Mid-Atlantic</i>	<i>Southeast</i>		<i>Gulf of America</i>		
Winter	3%	24%		13%		
Spring	3%	20%		8%		
Summer	1%	5%		4%		
Fall	4%	10%		4%		
<i>Activities with 5% or More of Total Impacts</i>		<i>Category</i>		<i>Percent of Total Impacts</i>		
Acoustic and Oceanographic Research (ONR)		Navy Testing		54%		
Line Charge Testing		Navy Testing		16%		
Bombing Exercise Air-to-Surface		Navy Training		13%		
<i>Area Type</i>	<i>Area Name (Active Months)</i>	<i>BEH</i>	<i>TTS</i>	<i>AINJ</i>	<i>INJ</i>	<i>MORT</i>
Critical Habitat	Northwest Atlantic Ocean (All)	25,746	2,709	34	-	-

Notes: BEH = Significant Behavioral Response; TTS = Temporary Threshold Shift; AINJ = auditory injury; INJ = Non-Auditory Injury, MORT = Mortality. For BEH, TTS, AINJ, INJ, and MORT annual estimated impacts: Zero (0) impacts indicate total less than 0.5 and a dash (-) is a true zero. The value (1) indicates up to one impact in a maximum year, but less than one per year on average across seven years.

Response Analysis

Given the above estimated exposures of ESA-listed sea turtles to acoustic stressors associated with the proposed action, in this section we describe the range of responses to these exposures. This includes behavioral responses, sound-induced hearing loss (i.e., TTS and AINJ), non-auditory injury, physiological stress responses, and masking. As discussed above for marine mammals (Section 6.1.1), our aim with this response analysis is to assess the potential responses that might reduce the overall fitness of individual ESA-listed sea turtles. Such responses would likely rise to the level of take under the ESA.

Non-Auditory Injury and Mortality

From our exposure analysis above, a small number of exposures to explosives are expected to result in non-auditory injuries for the following ESA-listed sea turtle species: green sea turtle – North Atlantic DPS, Kemp’s ridley, leatherback, and loggerhead Northwest Atlantic Ocean DPS. A small number of sea turtle mortalities from explosives are also anticipated as a result of the proposed action.

Based on what is known about potential sea turtle impacts from explosives, we assume underwater explosives can kill, injure, and impair sea turtles exposed to detonations. Lethal injuries can result from massive trauma or combined trauma to internal organs as a result of close proximity to the point of detonation. Types of lethal injuries include massive lung hemorrhage, gastrointestinal tract injuries (contusions, ulcerations, and ruptures), and concussive brain damage, cranial and skeletal (shell) fractures, hemorrhage, or massive inner ear trauma (Ketten 1995).

Non-lethal injuries can impact individual sea turtle fitness, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. Depending on the type of injury (e.g., severity, location) and other relevant factors (e.g., animal life stage, size, condition prior to exposure), a reduction in fitness from non-auditory injury could either be temporary with recoverable impacts, or result in long-term fitness consequences for some individuals. Examples of nonlethal injuries include eardrum rupture, bruising, and immobilization of severely stunned animals. Minor organ injuries and contusions can occur as a result of underwater explosions; however, some sea turtles would be expected to recover over time through normal healing processes. Stunned animals beneath the water may drown or become vulnerable to other impacts (e.g., vessel strike, predation) while they are immobilized. Still, delayed complications arising from nonlethal injuries may ultimately result in the death of the animal because of increased risks from secondary infection, predation, or disease; and a reduced foraging capacity.

Hearing Loss and Auditory Injury

Sea turtles are likely susceptible to hearing loss when exposed to high levels of sound within their limited hearing range (most sensitive from 100 to 400 Hz and limited over 1 kHz). Explosives are a broadband source (Hildebrand 2009a), so if a sea turtle experiences TTS or AINJ from explosives, a greater frequency band would be affected as compared to TTS or AINJ from narrow-band sonar sources. Air guns are also an impulsive, broadband sound source dominated by lower frequencies within the hearing range of reptiles. However, from our exposure analysis above, only a small number of ESA-listed sea turtles would be exposed to air gun noise at levels that could result in an adverse effect.

Because a greater frequency band would be affected due to explosives, there is increased chance that the hearing impairment will affect frequencies utilized by sea turtles for acoustic cues, such as the sound of waves, coastline noise, the presence of a vessel or predator. However, sea turtles are not known to rely heavily on sound for life functions (Popper et al. 2014), and instead, may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013) and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions. Sea turtles may use acoustic cues such as waves crashing, wind, vessel and/or predator noise to perceive the environment around them. If such cues increase survivorship (e.g., aid in avoiding predators, navigation), hearing loss may have effects on individual sea turtle fitness. TTS in sea turtles is expected to only last for a few hours to days, depending on the severity. Given this short period of time, and that sea turtles are not known to rely heavily on acoustic cues, we do not anticipate that TTS exposure would have fitness impacts on individual turtles. AINJ could permanently impair a sea turtle's ability to hear environmental cues, depending on the frequency of the cue and the frequencies affected by the hearing impairment. Given this longer time frame, we anticipate that at least some sea turtles that experience AINJ may have a reduction in fitness either through some slight decrease in

survivorship (e.g., decreased ability to hear predators or hazards such as vessels) or reproduction (e.g., minor effects to navigation that may reduce mating opportunities).

Behavioral Responses

Any acoustic stimuli within sea turtle hearing ranges in the marine environment could elicit behavioral responses in sea turtles, including noise from sonar, air guns, and explosions. Based on a limited number of studies, sea turtle behavioral responses to non-impulsive sounds could consist of temporary avoidance, increased swim speed, or no observable response (Lenhardt 1994; Lenhardt 2002). Similarly, based on a limited number of studies, sea turtle behavioral responses to impulsive sounds (i.e., air guns) could consist of temporary avoidance, increased swim speed, startle response, dive response, changes in depth; or there may be no observable response (O'Hara and Wilcox 1990; McCauley et al. 2000b; DeRuiter and Doukara 2012). There is no evidence to suggest that any sea turtle behavioral response to acoustic stressors would persist after the sound exposure. More information regarding studies on sea turtle behavioral responses to acoustic disturbance can be found in the AFTT BA (Section 4.3.2.1.1.4, pp. 4-278 through 4-280), which we incorporate here by reference (Navy 2024e).

Exposure to multiple detonations over a short period may cause a sea turtle to exhibit behavioral reactions such as interruption of feeding or avoiding the area. Exposure to a single blast during an event, which is the most probable scenario during AFTT activities, would more likely result in a short-term startle response. Sea turtles would presumably return to normal behaviors quickly after exposure to a single blast, assuming the exposure did not result in injury. Additionally, significant behavioral responses that result in disruption of important life functions are more likely to occur from multiple exposures within a longer period of time. This is unlikely to occur since most activities involving explosives occur in more discrete areas and would not likely persist for long enough periods of time to result in a significant, long-term behavioral response with fitness consequences. Therefore, while a large number of sea turtles may experience a behavioral response from exposure to explosives, the anticipated impacts on fitness and survival are minor and short-term.

Physiological Stress

ESA-listed sea turtles that experience either TTS, PTS, or a significant behavioral response are also expected to experience a physiological stress response. A short, low level stress response may be adaptive and beneficial for sea turtles in that it may result in sea turtles avoiding the stressor and minimizing their exposure. Whereas stress is an adaptive response that does not normally place an animal at risk, distress involves a chronic stress response resulting in a negative biological consequence to the individual. Stress responses from acoustic and explosive stressors resulting from AFTT activities are expected to be short-term in nature given that, in most cases, sea turtles would not experience repeated exposure to these stressors over a long period of time. As such, we do not anticipate stress responses would be chronic, involve distress, or have negative long-term impacts on any individual sea turtle's fitness.

Masking

Sea turtles likely use their hearing to detect broadband low-frequency sounds in their environment so the potential for masking would be limited to sound exposures that have similar characteristics (i.e., frequency, duration, and amplitude). Continuous and near-continuous human-generated sounds that have a significant low-frequency component, are not brief, and are of sufficient received level, are most likely to result in masking (e.g., proximate vessel noise and high-duty cycle or continuous active sonar). Other intermittent, short-duration sound sources with low-frequency components (e.g., air guns and explosives) would have limited potential for masking. Because sea turtles may rely primarily on senses other than hearing for interacting with their environment, any effect of masking may be mediated by reliance on other environmental inputs.

6.2.2 Vessel Strike Analysis

The majority of the proposed AFTT military readiness activities considered in this biological opinion involve vessel activity. While commercial vessel traffic is relatively steady throughout the year, Action Proponent vessel use within the action area is episodic, based on specific exercises being conducted at different times of the year and in different locations. Sea turtles must surface to breathe, and several species are known to either bask or feed at the surface for long periods. As such, sea turtles are vulnerable to being hit by a vessel transiting through areas where they may be resurfacing, resting or feeding at the surface. All of the ESA-listed sea turtles species present in the action area can occur at or near the surface, and therefore may be susceptible to strike from manned or unmanned surface vessels as part of the proposed action. Although we are not aware of any reported cases of a sea turtle being struck by a Navy or Coast Guard vessel or unmanned vehicle in the AFTT Action Area, unlike when a vessel strikes a large whale, it is often difficult to detect when a vessel strikes a sea turtle. This is due to the relatively small size of a sea turtle compared to most of the vessels used by the Action Proponents for military readiness training and testing activities.

Vessel use for AFTT activities resulting in strikes of sea turtles would most likely occur in areas that overlap high density sea turtle habitats, particularly nearshore foraging areas or directly off nesting beaches. Sea turtles are expected to be more highly dispersed in deeper offshore waters and, given the large open-ocean areas over which Action Proponent vessels could potentially conduct testing and training activities, the likelihood of co-occurrence is much lower in offshore waters. Leatherback turtles, in particular, could be impacted by offshore vessel movement given this species' preference for open-ocean habitats and its surface foraging behavior.

Sea turtle vulnerability to vessel strike increases with vessel speed. High speed vessel movements increase the potential risk of vessel strikes by reducing the available reaction time of both the sea turtle and vessel operators to an impending strike (Hazel et al. 2007). Hazel et al. (2007) found that vessel operators could not rely on turtles at the surface to actively avoid being struck for vessel speeds greater than four km/hr, well below the typical operating speeds of most Action Proponent vessels. Hazel et al. (2007) examined vessel strike risk to green sea turtles and

suggested that sea turtles may habituate to vessel sound and are more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in eliciting responses (Hazel et al. 2007). Regardless of what specific stressor associated with vessels turtles are responding, they only appear to show responses (avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). This is a concern because faster vessel speeds also have the potential to result in more serious injuries (Work et al. 2010).

In order to evaluate the circumstances that result in mortality or serious injury of sea turtles due to vessel strikes, we reviewed studies on the effect of vessel speed on lethal sea turtle injuries, as well as reported observations of sea turtle behavior in response to oncoming vessels. In tests of carapace damage resulting from vessel strikes of loggerhead sea turtles (Sapp 2010; Work et al. 2010), physical models simulating the shape and strength of loggerhead carapaces were placed in the water and struck at idle speed (3.8 knots), sub-planing speed (7.6 knots), and planing speed (21.6 knots). This study showed that vessel strikes at idle speed resulted in lethal damage to the carapace 25% of the time. Vessel strikes at planing speed resulted in 100% lethal damage. At sub-planing speeds (7.6 knots), the resulting large bow wave helped push the animal out of the way, resulting in no contact with the carapace 38% of the time. Action Proponent vessels may operate at different speeds, but some vessels reach high speeds that could cause death by blunt force trauma if the hull directly impacted a turtle as was tested in the study. Sea turtles struck by propellers may have a greater chance of surviving than those that incur blunt force on the carapace, which can expose the body cavity. The authors of the above studies noted that because the models were in a fixed position and directly hit in each test, the actual injury rate in free swimming sea turtles may be different due to the depth, orientation, and avoidance behavior of turtles in the wild. The studies also did not report the effect of vessel speed on propeller injury, and the results cannot be applied to all vessel-strike scenarios (Sapp 2010; Work et al. 2010).

In inshore and nearshore waters of the action area where higher sea turtle abundance makes vessel encounters more likely, Action Proponent vessel use occurs more regularly and is mainly from small, high-speed (greater than 10 knots) vessels. Propulsion testing (Section 2.4.4), which can involve vessels operating at speeds in excess of 30 knots, may pose an even greater strike risk of sea turtle strike due to the very high vessel speeds. More information on Navy and Coast Guard vessel activity in the AFTT action area can be found above in Section 2.4.4 (Physical Disturbance and Strike Stressors – Vessels) and in the AFTT Phase IV BA (Navy 2024c). For a more detailed discussion of the general threat of vessel strike to ESA-listed sea turtles in the action area see Section 5.11 (Environmental Baseline: Vessel Strike).

Exposure Analysis

The approach used to estimate sea turtle ship strikes is based on available strandings information (including cause of strandings) and the relative proportion of all vessel activity (e.g., commercial fishing vessels, non-fishing commercial vessels, recreational boats, cargo ships, ferries, cruise ships, and military vessels) within portions of the action area attributed to Action Proponent vessel activity. Our analysis focuses on the areas of greatest overlap between military vessel

activity and ESA-listed sea turtles (i.e., nearshore waters in close proximity to Action Proponent ports). The density of sea turtles is substantially lower in offshore waters compared to nearshore and inshore portions of the action area. Sea turtles struck by vessels far offshore are also less likely to strand than those struck in more nearshore waters. We have no empirical data to indicate Navy or Coast Guard vessels strike turtles in offshore waters, and also no data to indicate what percent of those that may be struck in offshore waters strand.

Within the action area, stranded sea turtles are usually discovered after washing up along shorelines that are directly adjacent to the Gulf of America or to the Atlantic Ocean, and often on open, sandy beaches of barrier islands (Foley et al. 2019). Strandings data can provide valuable information on minimum mortality at sea and likely causes of death attributed to both anthropogenic and natural factors (e.g., fishery bycatch, disease, or vessel strike). Autopsies of stranded turtles can often indicate the likely cause of stranding, including whether or not the turtle was struck by a vessel. Since it is possible that a vessel strike can occur post-mortem, vessel strike may not be the proximal cause of death in all stranded turtles exhibiting vessel strike wounds. In a study from Virginia, Barco et al. (2016) found that all 15 dead loggerhead turtles encountered with signs of acute vessel interaction were apparently normal and healthy prior to being struck. Similarly, Foley et al. (2019) found little evidence of post-mortem vessel strike in a large study of sea turtle strandings off the coasts of Florida from 1986-2014. It is unlikely that many sea turtles would happen to be struck by a vessel within hours of death from another cause, and a postmortem vessel strike is rare among stranded sea turtles that are found severely decomposed (Foley et al. 2019). Based on the results of their necropsies, Foley et al. (2019) conclude that a vessel strike injury in a stranded sea turtle almost always represents the cause of death. Therefore, for our analysis it is reasonable to assume that vessel strike was the likely cause of death for any stranded turtle with signs of vessel strike.

Estimating total at sea mortality based on reported strandings can prove challenging since stranding probabilities are usually very low and highly variable in space and time (Koch et al. 2013). Although sea turtle stranding rates are variable, strandings typically represent only a small portion of the total mortality, as predators, scavengers, wind, and currents prevent carcasses from reaching the shore (Koch et al. 2013). Previous studies suggest that the stranding probability of a sea turtle that dies at sea usually does not exceed 10-20% of total at sea mortality, even in nearshore waters (Epperly et al. 1996; Hart et al. 2006; Mancini et al. 2012; Foley et al. 2019). Depending on currents, wind and other factors, strandings may represent as low as 5% of total mortalities in some particular locations (Mancini et al. 2011). At greater distances from shore, strandings probability diminishes even more, and for animals that die far offshore stranding probabilities may approach zero. In addition, many strandings may never be noticed or recorded in a database, particularly in more remote areas or areas without sea turtle stranding monitoring programs. In such areas the observed stranding rate is likely even smaller than the stranding probabilities predicted by experimental studies.

For the AFTT action area, we use 10% as a reasonable, science-based estimate of the observed stranding probability. This estimate considers (1) the large geographic span of this area, (2) the physical factors (e.g., wind, currents, and bathymetry) in the open ocean portions of the action area that may prevent a carcass from stranding, and (3) the remote, less populated portions of the action area used by Navy or Coast Guard vessels, where unobserved strandings would be more likely to occur.

A few studies have reported live sea turtles with vessel strike injuries (Norem 2005; Deem et al. 2006; Blumenthal et al. 2009; Denkinger et al. 2013; Ataman et al. 2021). This indicates that under some circumstances vessel strikes can result in non-lethal effects to sea turtles. However, a study of sea turtle strandings records in southwest Florida from 1987-2021 suggests that sea turtles encountered as strandings have a very low likelihood of surviving vessel strikes long-term (Kincaid et al. in press). Approximately 95% of sea turtles with vessel strike injuries in this study were either dead upon recovery or died subsequent to rescue. Sea turtle injuries from vessel strike can lethally damage vital organs, result in fatal blood loss, lead to secondary infection, and cause chronic impairment and diminished fitness, sometimes leading to mortality later in life (Casal and Orós 2009; Foley et al. 2019; Phu and Palaniappan 2019). In addition, turtles who survive a vessel strike injury long enough for it to heal may suffer secondary health issues over time, such as reduced mobility which may increase the risk of future vessel strikes or predation, and neurogenic bowel dysfunction, which can ultimately lead to death (Kincaid et al. in press). While it is difficult to account for turtles who survive a vessel strike injury and never strand, results from this study suggest that, even though initial survivorship may be as high as 25%, the chance of long-term survival is extremely low, in general. The best available data suggest that collisions with vessels even at very low speeds can be lethal for sea turtles (Hazel et al. 2007; Sapp 2010; Work et al. 2010). Thus, in most instances, sea turtle survival of a vessel strike would only be possible for strikes by small vessels operating at slow speeds (i.e., less than 5 to 10 knots). For the proposed action, the large majority of Action Proponent vessel activity will be from large vessels and/or vessels operating above 10 to 15 knots. Given this, and the lack of data on non-lethal vessel strikes of sea turtles in the AFTT action area, for our effects analysis we focus on estimating lethal vessel strikes, which includes strikes resulting in immediate mortality and strikes resulting a serious injury that leads to mortality in the future. In doing so we rely on stranding data of sea turtles with evidence of vessel strike, and we apply a correction factor (i.e., 10% strandings probability from above) for unobserved vessel strikes that we believe reasonably captures and corrects for any non-lethal strikes that may occur as a result of the proposed action.

Combining available information on the number of reported strandings with evidence of vessel strike and the estimated stranding probability, we can arrive at an estimate of the total number of sea turtle vessel strikes within the action area. For purposes of our effects analysis, we then need to determine what proportion of the estimated sea turtles vessel strikes in the action areas are attributable to Action Proponent vessels as part of the action. To estimate vessel strikes by Action Proponent vessels we need to determine the proportional level of Action Proponent vessel activity relative to all vessel activity that can result in sea turtle vessel strike. Vessel activity can

be measured several ways, including number of ships/vessels, number of transits in and out of ports, or number of ship-hours on the water. Based on the information available for our analysis, we determined that ship-hours on the water was the best correlate of sea turtle ship strike risk. All other things being equal (e.g., vessel speed, vessel size, vessel noise, locations, and sea turtle densities), the number of vessel strikes should be roughly proportional to the number of vessel hours on the water.

Action Proponent vessels make up about 1% of total ship traffic in the AFTT action area. It should be noted that the vessel traffic analysis (Navy 2025a) only includes large vessels, generally those over 65 ft in length. Thus, smaller military and commercial vessels, and most pleasure craft are not included. We anticipate that, due to their generally larger sizes and faster speeds, a large proportion of sea turtle vessel strikes, particularly lethal strikes, within the action area would be from large commercial and military vessels. However, we recognize that sea turtles are also susceptible to vessel strike by smaller vessels including small military vessels, recreational boats, and small fishing vessels.

In general, susceptibility to vessel strike will be higher in inshore and nearshore areas with higher sea turtle densities and large volume of fast moving, small vessel traffic. The Action Proponents provided information on the estimated annual number of high speed (i.e., greater than 10 knots) vessel hours for small craft by range complex (Table 68). Based on this distribution of vessel hours, we would expect that the highest risk of sea turtle vessel strike in inshore areas would occur along the Atlantic Coast from Delaware through north Florida. Since sea turtle densities in the Northeast Atlantic are much lower than other portions of the action area, vessel strike would be unlikely to occur in this region. While, sea turtle densities are expected to be relatively high within inshore areas in the Gulf Range Complex, very little AFTT small craft vessel activity will occur in these areas. Overall, AFTT vessel traffic within the Gulf of America is much smaller than vessel traffic in the Atlantic; only 2% of Navy vessel hours and 16% of Coast Guard vessel hours are expected in the Gulf of America. As such, we expect that the large majority of vessel strikes resulting from the proposed action would occur in the Atlantic Ocean portion of the action area, particularly in the Mid-Atlantic and Southeast regions.

Table 68. Estimated AFTT Annual High Speed (i.e., greater than 10 knots) Vessel Hours for Small Craft in Inshore Locations by Range Complex (Navy 2024c)

Study Area Location	Habitat Area (km ²)	Maximum Annual # of Hours
Northeast Range Complex Inshore	366	9,502
VACAPES Range Complex Inshore	1,981	64,023
JAX Range Complex Inshore	67	17,995
Gulf Range Complex Inshore	1,137	56

Estimated Sea Turtle Vessel Strikes

For our quantitative exposure analysis, we first estimate the number of sea turtle vessel strikes (by species) in the Atlantic Ocean portion of the action area. We then extrapolate the total number, based on the ratio of Atlantic to Gulf of America vessel activity, to estimate the total number of sea turtle strikes in the Gulf of America. We then proportion the total number of anticipated vessel strikes in the Gulf of America by species based on the proportional species distribution of all vessel strike strandings in the Gulf of America.

We conducted a data query of the Sea Turtle Stranding and Salvage Network (STSSN) database to find the total number of sea turtles stranded along the Atlantic Coast (including Florida's Monroe County and the Florida Keys) for which the cause of stranding was likely vessel strike. This included data entries recorded as either "vessel strike" or "blunt force injury."

Some stranded turtles with signs of vessel strike or blunt force injury are still alive, and are either immediately released or taken to a rehabilitation facility. However, based on "fate" information recorded in the STSSN database, it is likely that an extremely small percent (less than 1%) of stranded turtles survive the incident and are immediately released alive, and a very small percent (less than 10%) survive and are successfully rehabilitated and then released alive. Additionally, as discussed above, since we expect the stranding probability to be around 10%, the large majority (about 90%) of vessel struck sea turtles in the action area would not strand and, therefore, would likely die (either immediate or delayed mortality) from their sustained injuries. The few turtles struck by vessels that strand alive would likely have serious injuries that may result in reduced fitness, increased vulnerability to other threats (e.g., predation and disease) and eventual mortality (Kincaid et al. in press). Thus, for purposes of our analysis, we assume that any sea turtle stranding caused by a Navy or Coast Guard vessel strike would result in either immediate or delayed mortality of that turtle.

We used STSSN data for the years 2019 to 2023 for our analysis. Although the time series used for our analysis includes years during the COVID pandemic, we have no information to indicate that this significantly affected the level of vessel activity or the number of boat strikes of sea turtles on the Atlantic Coast. The total number of stranded sea turtles on the Atlantic Coast with signs of vessel strike or blunt force injury was fairly consistent from year to year within this time series (i.e., high of 751 in 2020; low of 669 in 2022). The annual average number of stranded sea turtles on the Atlantic Coast with signs of vessel strike or blunt force injury from 2019 to 2023 was 716 turtles.

Based on our strandings probability analysis above, we estimate that the 716 sea turtles struck by all vessels annually represent about 10% of the total number of sea turtles along the Atlantic Coast that are struck annually by all vessels. Thus, our estimate of the total annual number of sea turtle vessel strikes (by all vessels) along the Atlantic Coast is 7,160 sea turtles. We recognize that this may overestimate vessel strikes within the AFTT action area, since some of these strikes may have occurred outside of the AFTT action area.

Based on the best available information (Navy 2025a), we estimate that Action Proponent vessels account for about 1% of all vessel traffic in the Atlantic Coast portion of the action area. The actual proportion is difficult to estimate because vessel tracking systems typically do not include smaller vessels (military or nonmilitary). In addition, both the proportion of vessel traffic accounted for by AFTT vessels and the number of sea turtle vessel strikes will vary greatly by location, season, distance from shore, as well as other factors. Therefore, we use 1% as a reasonable approximation (based on the best available information) of the proportion of total sea turtle vessel strikes on the Atlantic Coast that are attributable to Action Proponent vessels as part of the proposed action. Our annual estimated number of sea turtle vessel strikes along the Atlantic Coast as a result of the proposed action is calculated as 1% of the total annual number of sea turtle vessel strikes by all vessels along the Atlantic Coast: i.e., $7,160 \times 0.01 = 72$ sea turtles.

Next, we extrapolate, based on the ratio of Gulf of America to Atlantic Coast vessel activity, to estimate the annual number of sea turtle strikes in the Gulf of America as a result of the proposed action. Based on information provided by the Action Proponents, the estimated annual average number of large (> 65 ft) vessel at-sea days is 2,815 for the Navy and 1,555 for the Coast Guard, 4,370 total. We multiply these estimates by the proportion of AFTT vessel activity anticipated in the Gulf of America (2% for Navy; 16% for Coast Guard) to get 305 ($249 + 56$) annual at-sea days in the Gulf of America and 4,065 (i.e., $4,370 - 305$) annual at-sea days in the Atlantic. The ratio of Gulf of America vessel activity to Atlantic Coast vessel activity is: $305/4,065 = 0.075$. Although this ratio is based on data from only large vessel activity (i.e., detailed vessel traffic data are not available for smaller vessels), for purposes of this analysis we assume that it is representative of the ratio for all sized AFTT vessels. Multiplying the calculated ratio of 0.075 by our estimate of the annual number of sea turtle vessel strikes along the Atlantic Coast (72 sea turtles), we get an estimated 5.4 annual sea turtle vessel strikes in the Gulf of America as a result of the proposed action, which we round up to 6 sea turtles.

The next step in our sea turtle vessel strike exposure analysis is to determine which ESA-listed sea turtle species would be exposed and the number of strikes per species (out of the 72 Atlantic Coast and 6 Gulf of America strikes annually) resulting from the proposed action. For the distribution of Atlantic Coast sea turtle vessel strikes by species, we used STSSN database records with vessel strike and/or blunt force injury indicated), for the years 2019 to 2023, and the Atlantic states from Maine through Florida (East Coast, including Monroe County and the Florida Keys). The proportional distribution by species, based on 3,572 sea turtle strandings records with the species identified, is: loggerhead sea turtle 38.9%; green sea turtle 49.0%; leatherback sea turtle 2.5%; hawksbill sea turtle 0.2%; and Kemp's ridley sea turtle 9.4%. Applying these proportions to the annual estimate of 72 annual sea turtle vessel strikes, after rounding, we get the following estimated annual strikes by species in the Atlantic portion of the action area: 28 loggerhead sea turtles; 35 green sea turtles; 2 leatherback sea turtles; 1 hawksbill sea turtle; and 7 Kemp's ridley sea turtles.

For the distribution of the Gulf of America sea turtle vessel strikes by species, we used STSSN database records with vessel strike and/or blunt force injury indicated), for the years 2019 to 2023, and the Gulf states from Texas through Florida (West Coast). The proportional distribution by species, based on 2,352 sea turtle strandings records with the species identified, is: loggerhead sea turtle 31.0%; green sea turtle 54.3%; leatherback sea turtle 0.4%; hawksbill sea turtle 0.0%; and Kemp's ridley sea turtle 14.2%. Applying these proportions to the annual estimate of six sea turtle vessel strikes, after rounding, we get the following estimated annual vessel strikes, by species, in the Gulf of America portion of the action area: 2 loggerhead sea turtles; 3 green sea turtles; 0 leatherback sea turtles; 0 hawksbill sea turtle; and 1 Kemp's ridley sea turtle.

Combining the Atlantic Coast and Gulf of America estimates, we arrive at the following annual vessel strike estimates, by species, throughout the AFTT action area as a result of the proposed action: 30 loggerhead sea turtles; 38 green sea turtles; 2 leatherback sea turtles; 1 hawksbill sea turtles; and 8 Kemp's ridley sea turtles. Our estimated number of vessel strikes, by species, throughout the AFTT action area every 7-year period of the proposed action is: 207 loggerhead sea turtles; 266 green sea turtles; 13 leatherback sea turtles; 1 hawksbill sea turtle; and 52 Kemp's ridley sea turtles²⁵.

These estimates include vessel strikes by both Navy and Coast Guard vessels. We combined the Navy and Coast Guard for this analysis since, unlike the case for large whales (Section 6.1.2), we do not have a historical record of Navy and Coast Guard vessel strike incidents involving sea turtles. The best available information we have to split these estimates between Navy and Coast Guard vessels is relative proportion of AFTT vessel activity that each accounts for. Based on historically vessel activity data (i.e., at-sea days) in the AFTT action area, we anticipated that the Navy will account for about 61% of AFTT Phase IV vessel activity. Therefore, we expect about 61% of sea turtle vessel strikes as a result of the proposed action will be from Navy vessels, and about 39% will be from Coast Guard vessels.

Anticipated Life Stages and Sex Ratios of Sea Turtle Vessel Strikes

Next, we consider the life stages of sea turtles that could be impacted by vessel strike as a result of the proposed action. Sea turtles vessel strikes are most likely occur in areas of overlap between high densities of sea turtles, high volume of AFTT vessel traffic, and military readiness activities involving vessels operating at high speeds. Within the action area, coastal foraging habitats exist for all sea turtle species over the continental shelf and within inshore waters. In these areas, juveniles, sub-adults, and adults of all species are at risk of vessel strike. Near nesting beaches, hatchlings of all sea turtle species would also be present, but very briefly as they leave the nest, enter the water, and move to offshore areas to mature. Hatchlings would only be present a few months of the year between summer and fall in the action area from southern Virginia southward. Only green, Kemp's ridley, and loggerhead turtles are expected to be located

²⁵ Note: Seven year estimates are not always seven times the maximum annual estimate due to rounding at different stages of the analysis for each calculation.

in nesting areas as far north as Virginia. Leatherback turtles may nest as far north as North Carolina. Hawksbill turtles rarely nest in parts of Florida (USFWS 2013).

For training and testing exercises occurring in the deeper, offshore waters of the action area, the life stages most likely to be impacted are hatchlings and pre-recruitment juveniles of all sea turtle species, all life stages of leatherback sea turtles, and occasionally adult loggerheads. In general, sea turtles are expected to be highly dispersed in deeper offshore waters and, given the large area over which Action Proponent vessels could potentially conduct AFTT activities, the likelihood of co-occurrence is much lower in deeper, offshore waters as compared to nearshore coastal and inland areas.

Hatchlings and pre-recruitment juveniles of all sea turtle species may also occur in open-ocean habitats, where they are often associated with floating *Sargassum* habitats. For example, Witherington et al. (2012a) found that approximately 89% of post-hatchling and juvenile green, Kemp's ridley, loggerhead, and hawksbill sea turtles were within 1 m of floating *Sargassum* based on surveys in the Gulf of America and off the east coast of Florida. Even for those small turtles not within 1 m of *Sargassum*, 78% of the time the closest object was still *Sargassum* and there was only one observation of a small sea turtle not associated with a floating object (within approximately 100 m). As such, the majority of smaller sea turtles (i.e., less than 30 cm in diameter) within the action area are expected to be associated with *Sargassum* habitat. The association between small leatherback sea turtles and *Sargassum* habitat is less clear (Wyneken and Salmon 1992; Salmon et al. 2004). Therefore, we do not necessarily expect the majority of small leatherback sea turtles in the action area to be associated with *Sargassum* habitat, and instead assume they would be dispersed throughout the action area.

Gower and King (2011) used satellite imagery to estimate the seasonal extent of *Sargassum* in the North Atlantic and Gulf of America, which provides some insight into where the majority of the small green, Kemp's ridley, hawksbill, and loggerhead sea turtles are likely to be found relative to the proposed action. In addition, loggerhead and green sea turtle designated critical habitat includes areas expected to be covered by *Sargassum* at some point during the year (See Section 4.1.3, Figure 10). While this critical habitat unit was designated specifically for loggerhead and green sea turtles, it likely contains small sea turtles of all hardshell species regularly found within the action area. Based on the location of loggerhead and green sea turtle *Sargassum* critical habitat and the areas identified by Gower and King (2011), a large proportion of the action area is expected to be covered by *Sargassum* at some point during the course of a year. We expect that the majority of small green, Kemp's ridley, hawksbill, and loggerhead sea turtles will be found in *Sargassum* habitat.

As part of the proposed action, the Action Proponents proposes to use Lookouts to observe for floating vegetation, which would include *Sargassum*. If floating vegetation is observed, the vessel would avoid initiating activities involving acoustic and explosive stressors until it passes outside of the mitigation zone, or move to another area avoiding the *Sargassum* rafts. While the proposed action does not include an explicit measure for vessels to avoid traveling through

floating vegetation, which would decrease the chances of a ship strike of a small sea turtles, we anticipate that in most cases the Action Proponents will avoid traveling through *Sargassum*. This is because in many cases Lookouts would observe *Sargassum* and notify vessel operators to avoid it, and because depending on the density of the *Sargassum* and the size of the vessel, traveling through such floating vegetation may cause it to become entangled in the vessel's propeller, possibly causing it to malfunction or be damaged. Nonetheless, we are unable to quantitatively account for this mitigation.

We used information from the STSSN database to approximate the proportional distribution of sea turtle vessel strikes as a result of the proposed action between males and females for each species. Sex ratios were based on all strandings records from 2014-2023, Maine through Texas, for which the likely cause of stranding was vessel strike. For the majority of strandings records (~ 75%), sex is recorded as "undetermined" because, without an internal examination, it typically can only be determined if the animal is an adult and if the carcass is in good condition. However, we still consider the STSSN database to be the best available information to approximate the distribution of AFTT vessel strikes by sex. While sea turtle sex ratios are reported in the literature for some species, life stages, and particular locations (both within and outside of the AFTT action area), we are not aware of any studies that cover the entire action area or all life stages that could be struck by vessels. In addition, sex ratios based on vessel strike strandings records are more likely to account for any differences in vessel strike risk rates between males and females, if such differences exist, than are sex ratios reported in studies based on live sea turtles.

For all five ESA-listed sea turtle species in the AFTT action area, sex ratios based on strandings records in the STSSN database are biased towards female (Table 69). This is consistent with skewed sea turtle sex ratios reported in the published literature, likely due to a warmer environmental conditions on nesting beaches (Laloë et al. 2024). For example, Hays et al. (2014) searched the published literature to assemble a database on hatchling sex ratios for sea turtle breeding sites across the globe. Out of 46 articles, including data collected from 1977-2011, a male biased sex ratio was reported in just four records, and only two studies supported a balanced sex ratio (Hays et al. 2014). Nine of the 46 articles were studies conducted within the AFTT action area: all loggerhead sea turtles studies from North Carolina through Florida. While loggerhead sex ratios from these studies ranged widely (i.e., 50% to 100% female), four studies reported sex ratios between 50% and 60%, which is consistent with the sex ratio (53%) we found in the STSSN stranding records.

Table 69. Estimated Sex Ratios of Sea Turtle Vessel Strikes as a Result of the Proposed Action, based on STSSN Strandings Database Records from 2014-2023

<i>Sea Turtle Species</i>	<i>Total Records with Sex Determined</i>	<i>Female Percent</i>	<i>Male Percent</i>
Green – North Atlantic DPS	1,056	67%	33%
Hawksbill	3	67%	33%
Kemp’s Ridley	399	61%	39%
Loggerhead – Northwest Atlantic DPS	1,165	53%	47%
Leatherback	96	58%	42%

Response Analysis

From our exposure analysis above, we assume that any sea turtle strike as a result of the proposed action would result in either immediate or delayed mortality. Collisions with vessels would likely result in blunt trauma, lacerations, or mortality. Some sea turtles may be compromised and sustain infection, have reduced foraging abilities, experience higher predation risks, or die some time later as a result of vessel strike injuries. While some sea turtles may initially survive a vessel strike injury, given the average size and speed of Action Proponent vessels, the chance of long-term survival is extremely low (Kincaid et al. in press).

6.3 Fishes

This section addresses the effects of sonar and other transducers, air guns, in-water explosives, and vessel strikes on the ESA-listed fish in the action area.

6.3.1 Acoustic and Explosives Effects Analysis

The Navy worked with NMFS to develop thresholds or use thresholds developed by others, based on what NMFS considers to be the best available scientific information on the effects of anthropogenic sounds on fishes. For many of the HCTT acoustic stressors affecting fishes in the action area we rely on recommendations in the 2014 ANSI Technical Report (*Sound Exposure Guidelines for Fishes and Sea Turtles*) as a starting point (Popper et al. 2014). More recent information from published research has been incorporated into this analysis, as available and relevant for purposes of our fish acoustics effects analysis.

None of the studies researching fish hearing have documented PTS impairment from various sound sources. This is attributed to the ability of fish to regenerate inner ear hair cells. Marine mammals and sea turtles are not known to have this ability. Hearing loss in fish is considered recoverable, although the rate of recovery is based upon the degree of the TTS sustained. Thus, auditory impairment in fish is considered recoverable over some duration; and auditory impairment thresholds are based solely on the onset of TTS for fish.

For barotrauma (e.g., physical injuries and mortality) in fish, NMFS and the Navy apply a peak pressure metric criteria. For hearing impairment (i.e., TTS), NMFS and the Navy apply a SEL_{cum}

threshold. NMFS also applies an RMS sound pressure level threshold for some acoustics sources to assess whether behavioral responses may be elicited during some sound exposures.

Sonar

General categories and characteristics of the sonar and other transducer systems proposed for use during AFTT activities are described in Sections 2.2 and 2.4.1.

Because of the sheer number and diversity of fishes, only a limited number of species have had hearing capabilities tested. Figure 62 provides a summary of hearing threshold data from available literature to demonstrate the potential overall range of frequency detection for each hearing group. These estimated hearing ranges may be overly conservative in that they may extend beyond actual species hearing capabilities for a particular group. The upper bounds of each fish hearing group frequency range are outside of the range of best sensitivity for all fishes within that group. As a result, fishes within each group would only be able to detect those upper frequencies from sources with relatively high source levels. Figure 62 is not intended as a composite audiogram, but rather displays the basic overlap in potential detectable frequencies for each fish hearing group associated with the AFTT defined sonar classes described in Section 2.4.1.

To evaluate the effects of sonar use during AFTT activities, we use the criteria for sonar and fishes based upon the recommendations provided in the 2014 ANSI Technical Report (Popper et al. 2014). The recommended threshold for onset of TTS for fish with a swim bladder that is not involved in hearing would be low-frequency sonar exposure levels greater than 210 dB SEL_{cum} re 1 $\mu\text{Pa}^2\text{-s}$. TTS has not been observed from exposure to mid-frequency active sonar in fish species within this hearing group. Fishes within this hearing group, which include the ESA-listed sturgeon and salmon species considered in this opinion, do not sense pressure well and typically cannot hear at frequencies above 2 kHz (Halvorsen et al. 2012; Popper et al. 2014). Therefore, no criteria have been proposed for fishes with a swim bladder that is not involved in hearing from exposure to mid-frequency active sonar. Since the other ESA-listed fish considered in this opinion (i.e., sharks, rays and sawfish) lack a swim bladder their sensitivity to low-frequency sonar is expected to be less than for those species with a swim bladder.

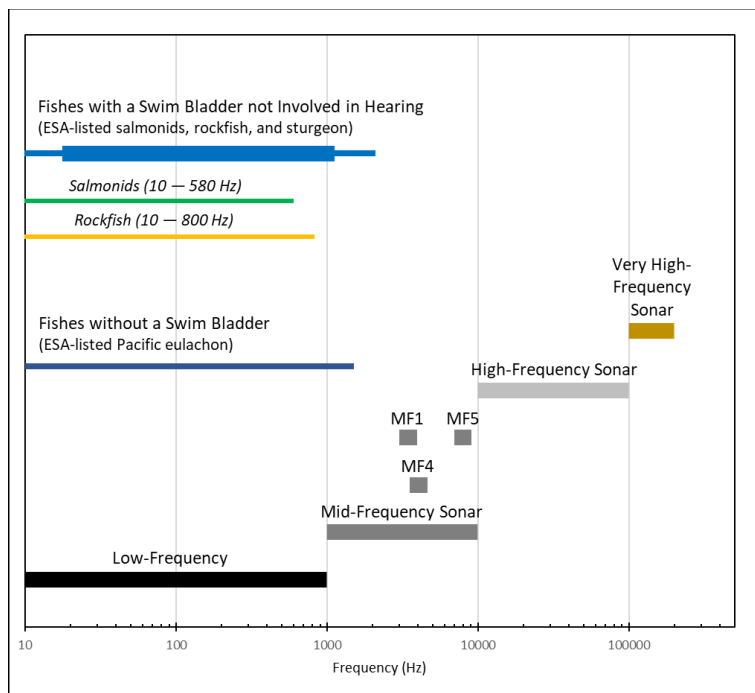


Figure 62. Hearing Frequency Ranges (pressure) of Some ESA-listed Fish Groups Compared to Navy Defined Sonar Classes. Sources: (Tavolga and Wodinsky 1963; Hawkins and Johnstone 1978; Popper et al. 2007; Popper 2008; Popper et al. 2014).

Figure 62 Notes: 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. When available, hearing data for specific ESA-listed species, or surrogate species, are provided (see green and yellow lines). Although the horizontal black, grey and brown bars represent each sonar class graphically, not all sources within each class would operate at all the displayed frequencies. Example mid-frequency classes are provided to further demonstrate this. MF1 = 3.5 kHz, MF4 = 4 kHz, MF5 = 8 kHz.

All ESA-listed fishes considered in this opinion have the potential to be exposed to sonar and other transducers during AFTT activities in the action area. As described previously, fishes are not equally sensitive to noise at all frequencies. Some species of fishes have specialized adaptations which increases their ability to detect sounds at higher frequencies. However, none of the ESA-listed fishes that may be affected by AFTT activities possess any hearing specializations, and all hear primarily below 2 kHz. For these reasons, grouping fish according to the presence of a swim bladder and whether or not that swim bladder is involved in hearing and their known hearing frequency ranges (audiograms) was determined to be the best approach for our analyses. Of the ESA-listed fish species considered in this analysis that possess a swim bladder (i.e., Atlantic sturgeon, Gulf sturgeon, and Atlantic salmon), none have a swim bladder that is associated with hearing. Thus, the sound criteria used for our analysis of the acoustic effects on fishes are based upon fishes with swim bladders not involved in hearing.

Exposure to Surveillance Towed Array Sensor System (SURTASS) low-frequency active sonar has been tested at maximum received levels of 193 dB re 1 μ Pa (218 dB SEL_{cum}) and has not been shown to cause mortality or any injury in fish with swim bladders (Popper et al. 2007; Kane et al. 2010). The researchers exposed three freshwater species of fish, the rainbow trout (*Oncorhynchus mykiss*), channel catfish (*Ictalurus punctatus*), and the hybrid sunfish (*Lepomis sp.*), to both low- and mid-frequency sonar. Low-frequency active sonar exposures with received SPLs of 193 dB re 1 μ Pa occurred for either 324 or 648 seconds. Although this laboratory study exposed the fish to low-frequency active sonar pulses for time intervals that would be substantially longer than what would occur in the wild (e.g., unconfined fishes), the exposed fish did not experience mortality or damage to body tissues at the gross or histological level. Hearing was measured both immediately post-exposure and for several days thereafter. Catfish and some specimens of rainbow trout showed a temporary hearing loss of 10 to 20 dB immediately after exposure to high intensity low-frequency active sonar when compared to baseline and control fish; however, another group of rainbow trout showed no hearing loss. Recovery in trout took at least 48 hours, but studies on recovery were not completed. The reason for the different results between rainbow trout groups is not known, although the researchers speculated it may be due to developmental or genetic differences in the various groups of fish. Catfish hearing returned to, or close to, normal within about 24 hours after exposure to low-frequency active sonar.

Furthermore, examination of the inner ears of the fish during necropsy revealed no differences from the control groups in ciliary bundles or other inner ear features indicative of hearing loss (Kane et al. 2010). Lesser potential for injurious effects would be expected for fish without swim bladders, because the presence of a swim bladder increases risk of injury as the sound wave passes through a fish's body and causes the swim bladder to resonate with the sound frequency.

No studies have indicated any physiological damage to adult fish from mid-frequency sonar. However, one study on juvenile herring survival found that intense sonar exposures affected less than 0.3% of the total juvenile stock (Kvadsheim and Sevaldsen 2005). Similarly, Jorgensen et al. (2005) exposed larvae and juvenile Atlantic herring (*Clupea harengus*) Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*), and spotted wolffish (*Anarhichas minor*) to sounds that were designed to simulate mid-frequency active sonar transmissions (1 to 6.5 kHz) to study the effects of the exposure on the survival, development, and behavior. The fish were placed in plastic bags 3 m from the sound source and exposed to between four and 100 pulses of one-second duration of pure tones at 1.5, 4, and 6.5 kHz. The fish in only two groups out of the 42 tested exhibited adverse effects beyond a behavioral response. These two groups were both composed of herring (a fish with hearing specializations), and were tested with SPLs of 189 dB re 1 μ Pa, which resulted in a post-exposure mortality of 20 to 30%. In the remaining 40 tests, there were no observed effects on behavior, growth (length and weight), or the survival of fish that were kept as long as 34 days post exposure. While statistically significant losses were documented in the two groups impacted, the researchers only tested that particular sound level once, so it is not known if this increased mortality was due to the level of the test signal or to other unknown factors. It is also important to note that none of the ESA-listed fish species considered in this

biological opinion have the hearing specializations similar to herring. As such, the ESA-listed fishes evaluated in this opinion are not considered as sensitive to sound exposures and associated hearing damage as herring.

In another mid-frequency active sonar experiment, Halvorsen et al. (2012) exposed rainbow trout to simulated mid-frequency active (2.8 to 3.8 kHz) sonar at received SPLs of 210 dB re 1 μ Pa, resulting in cumulative SELs of 220 dB re 1 μ Pa. The researchers did not observe any mortality or hearing sensitivity changes in rainbow trout and suggested that the frequency range of mid-frequency active sonar may be above the most sensitive hearing range of the species.

Some studies have suggested that there may be some loss of sensory hair cells due to high intensity sources; none of these studies concurrently investigated effects on hearing. Enger (1981) found loss of ciliary bundles of the sensory cells in the inner ears of Atlantic cod following one to five hours of exposure to pure tone sounds between 50 and 400 Hz with an SPL of 180 dB re 1 μ Pa. Similarly, Hastings (1995) found auditory hair-cell damage in a species with notable anatomical hearing specializations, the goldfish (*Carassius auratus*) exposed to 250 Hz and 500 Hz continuous tones with maximum peak levels of 204 dB re 1 μ Pa and 197 dB re 1 μ Pa, respectively. Compared to Navy sonar exposures anticipated, these were long duration exposures of about two hours in laboratory settings, much longer than any exposure a fish would encounter in the wild during the Navy's proposed activities (i.e., due to the transient nature of Navy sonar use and that fishes are not confined in the wild as they are in a laboratory setting). The fish exposed in the lab were held in a cage for the duration of the exposure, unable to avoid the source.

Hastings et al. (1996) demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) following a 1-hour exposure to a pure tone at 300 Hz with a peak pressure level of 180 dB re 1 μ Pa. Although in none of the studies was the hair cell loss more than a relatively small percent (less than a maximum of 15%) of the total sensory hair cells in the hearing organs.

Hastings (1990) and Hastings (1995) also demonstrated 'acoustic stunning' (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*) following an 8-minute exposure to a 150 Hz pure tone with a peak SPL of 198 dB re 1 μ Pa. This species of fish has an air bubble in the mouth cavity directly adjacent to the animal's braincase that may have caused this injury. The researchers also found that goldfish exposed to two hours of continuous wave sound at 250 Hz with peak pressures of 204 dB re 1 μ Pa, and gourami exposed to 0.5 hours of 150 Hz continuous wave sound at a peak level of 198 dB re 1 μ Pa did not survive. The only study on the effect of exposure of the lateral line system to continuous sound was conducted on a freshwater species, and suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

The research described above, and the most recent literature review and summary completed by Popper et al. (2014) regarding fish response to low-frequency active and mid-frequency active sonar indicate that those species tested to date can be used as viable surrogates for estimating injury in other species exposed to similar sources. The research conducted to date has not

provided evidence that injury or mortality could occur from the sonar used by the Action Proponents. Although fishes have been injured and killed due to intense, long duration, non-impulsive sound exposures, fish exposed under more realistic conditions have shown no signs of injury. Exposures would need to be of a much longer duration than those that would realistically occur with the proposed AFTT activities. In addition, the relative risk of injury or mortality to fish with no swim bladders (i.e., sharks and rays) exposed to low and mid-frequency sonar is lower than fish with swim bladders, no matter the distance from the source.

Based on the studies discussed above and other research, direct injury from sound levels produced from the type of sonar the Action Proponents use has not been documented in fishes (Popper et al. 2007; Kane et al. 2010; Halvorsen et al. 2012; Popper et al. 2013; Popper et al. 2014). These sound sources are considered to pose less risk to fish species because the sound produced from sonar and other transducers characteristically has lower peak pressures and slower rise times than other acoustic stressors that are known to injure and kill fish (e.g., impulsive sounds from pile driving, or the strong shock waves produced from detonation of explosives). Therefore, injury of ESA-listed fish from sonar is extremely unlikely (i.e., discountable), and is not considered further in this analysis. Therefore, potential impacts from exposure to AFTT sonar on ESA-listed fish are limited to TTS, masking, physiological response (including stress), and behavioral reactions.

Most marine fishes, including all ESA-listed species within the action, are either hearing generalists or lack a swim bladder, and would be unable to detect frequencies greater than approximately 2 kHz. Based upon the fish hearing and frequency overlap, the ESA-listed fishes considered in this biological opinion would have limited ability to detect mid-frequency active sonar frequencies, and would not likely be able to detect mid-frequency active sonar sources proposed for AFTT. Further, none of the fish species considered in this opinion can detect high- and very high-frequency sonars and other transducers. Therefore, ESA-listed fish species considered in this opinion are extremely unlikely to be affected by either mid-frequency or high-frequency sonar sources.

The AFTT proposed action includes a relatively small number of activities involving low-frequency sonar use in areas that would overlap with ESA-listed fish species. ESA-listed fish species may only detect low-frequency sonar systems with higher source levels within a few km; and most other, less powerful low-frequency sonar systems, at much shorter ranges. The Action Proponents performed a quantitative analysis using NAEMO and varying potential exposure durations (1, 30, 60 and 120 seconds) to estimate ranges to TTS for fishes exposed to AFTT sonars (Navy 2024c). Calculated ranges to TTS from low-frequency sources, regardless of exposure duration (1 to 120 s), resulted in estimated ranges of zero meters for all fishes and therefore TTS is not anticipated (Navy 2024c).

Fishes that are able to detect low-frequency active sonar, and perhaps some mid-frequency active sonar, could experience brief periods of masking, or exhibit brief behavioral reactions and stress responses. Fish located closer to the sonar sound source would likely experience more

substantive responses, whereas fish located further away from the source are less likely to react to the sound levels. However, because AFTT sonar sources are continuously moving, and fish are also capable of moving away from the disturbance, the overall exposure duration is expected to be brief. If masking did occur, it would not occur for a significant amount of time, nor would it likely prevent fish from detecting biologically relevant cues at meaningful levels. Additionally, any physiological stress responses or behavioral reactions would also be expected to be temporary, lasting only a few seconds or minutes during sonar pings. For these reasons, no long-term consequences for any exposed ESA-listed fish are expected, and the effects described above are not anticipated to lead to a significant disruption of normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. As such, the effects from sonar and other transducers on ESA-listed fish are considered insignificant, and, thus, may affect but are not likely to adversely affect these species in the action area.

Air Guns

The introduction of anthropogenic noise from airgun operations or other non-explosive impulsive sounds into marine environments triggers complex behavioral modifications in fish populations and may cause injury or mortality in fishes. These responses, which range from immediate startle reactions to prolonged changes in swimming patterns and social behaviors, represent significant adaptations that may impact both individual fitness and population dynamics. Understanding these behavioral changes is crucial for evaluating the environmental impacts of naval operations and developing effective mitigation strategies. As stated in previous sections addressing marine mammals and sea turtles, the Action proponents employ airguns primarily during specific testing activities, particularly for shock testing of naval vessels. Air gun use would only occur nearshore at Newport, Rhode Island, and typically greater than 3 NM from shore in the Northeast, VACAPES Range Complex, JAX, and GOMEX Range Complexes. The breakdown of location and maximum number of days for airgun operations are shown in Table 70 below.

Table 70. Location and Days of Airgun Operations within AFTT (Navy 2024c)

<i>Location</i>	<i>Days per Year</i>
Gulf Range Complex	11-12
JAX Range Complex	11-12
Northeast Range Complexes	11-12
VACAPES Range Complex	11-12
Newport, RI	4

These operations typically involve arrays of synchronized and phased seismic airguns that produce controlled pressure waves (Thompson 2003). The airguns operate at pressures around 2000 psi, creating substantial acoustic energy that propagates through the marine environment (Thompson 2003). This controlled application differs significantly from traditional explosive

testing, offering certain advantages in terms of environmental impact and operational flexibility (Thompson 2003).

When airguns are deployed, their effects on marine life can extend considerable distances from the source. Research indicates that behavioral impacts may occur at distances of approximately 2 km from typical airgun arrays operating in water depths of 100 to 120 m (Weilgart 2013). As fish respond to increasing airgun noise levels, they typically exhibit behavioral modifications such as moving to deeper waters and altering their swimming patterns. These behavioral responses suggest that the impact zone extends well beyond the immediate vicinity of testing activities. When exposed to airgun noise, fish demonstrate several immediate behavioral responses that reflect their acute sensitivity to acoustic disturbance. The behavioral impacts of airgun exposure extend beyond direct physiological effects. Fish responses to airgun operations can include altered swimming patterns, changes in schooling behavior, and modifications to feeding activities (Slabbekoorn et al. 2019). These behavioral changes, while often temporary, may have particular significance for ESA-listed species that already face multiple environmental stressors. The stress induced by airgun noise has been documented to physically affect marine life and potentially compromise overall fish health (Slabbekoorn et al. 2019).

Fish demonstrate several immediate behavioral responses that reflect their acute sensitivity to acoustic disturbance. Studies have documented that fish typically respond to increasing airgun noise levels by moving toward the bottom of the water column and swimming at accelerated speeds (Peng et al. 2015). These initial reactions often manifest as startle responses, which can be particularly pronounced in various species including seabass (*Dicentrarchus labrax*) and other commercially important fish (Peng et al. 2015). The intensity of these responses appears to vary among species, suggesting that behavioral reactions to noise are influenced by multiple variables including the fish's location, physiological state, age, body size, and school size. 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 pallid sturgeon (*Scaphirhynchus albus*) and paddlefish (*Polyodon spathula*) to a single shot from an air gun array (four air guns) within similar ranges (6 m) did not result in any signs of mortality within seven days after exposure (Popper et al., 2016).

Elasmobranchs (e.g., sharks, rays, and sawfish), like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings 2005; Popper 2009). Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012; Casper and Mann 2009; Casper 2006; Ladich and Fay 2013; Myrberg Jr. 2001; Yan 2003). However, unlike most teleost fish, elasmobranchs do not have swim bladders (or any other air-filled cavity), and thus are unable to detect sound pressure (Casper et al. 2012). Particle motion is presumably the only sound stimulus that can be detected by elasmobranchs (Casper et al. 2012). Given their assumed hearing range, elasmobranchs are anticipated to be

able to detect the low frequency sound from an airgun array if exposed. However, the duration and intensity of low-frequency acoustic stressors and the implementation of mitigation measures will likely minimize the effect this stressor has on elasmobranchs. Furthermore, although some elasmobranchs have been known to respond to anthropogenic noise, in general elasmobranchs are not considered particularly sensitive to noise (Casper et al. 2012).

One of the most consistently observed responses to airgun noise involves modifications to swimming behavior and school organization. Fish typically respond by forming more tightly cohesive groups and altering their swimming patterns (Peng et al. 2015). This behavioral adaptation may serve as a protective mechanism, potentially enhancing group coordination during periods of acoustic stress. Research has shown that these changes in swimming behavior can persist throughout the duration of noise exposure, with fish exhibiting increased alarm responses and modified movement patterns (Peng et al. 2015). Airgun noise can also significantly influence how fish utilize their habitat. Studies have documented that fish often exhibit clear avoidance responses to vessel noise and other anthropogenic sounds (Peng et al. 2015). This avoidance behavior can manifest as both horizontal and vertical displacement, with fish moving away from noise sources or changing their depth in the water column. Such spatial reorganization may have particular significance in areas where essential behaviors such as feeding or spawning typically occur (Peng et al. 2015).

The precise expected response of ESA-listed fishes to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for these species. However, given the signal type of and level of exposure to the low-frequency signals used in seismic survey activities, we do not expect adverse effects (including significant behavioral adjustments, TTS, PTS, injury, or mortality). 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 has not caused mortality, and fishes typically recovered from injuries in controlled laboratory settings. Barring other proxies to rely upon, species tested to date can be used as surrogates for investigating injury in other species exposed to similar sources (Popper et al. 2014). The most likely response of ESA-listed fishes exposed to airguns operations, if any, will be minor temporary changes in their behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of ESA harassment. If these behavioral reactions were to occur, they will not have fitness impacts for the individual, the populations, or the DPS. Fitness impacts could include reduced foraging ability, reduced reproducing ability, avoidance, increased swimming speed, erratic behavior, startle, and stress; however, we expect any such responses will be minor and short-term, with no resulting fitness consequences.

In summary, due to the limited use and relatively small footprint of air guns, although some individuals may be harmed if they are co-located with air gun activities, impacts to individual fish are expected to be minor and insignificant. Therefore, we conclude that noise from airgun

arrays may affect, but is not likely to adversely affect ESA-listed fish within the AFTT action area.

Explosives

NMFS does not currently have “formal” criteria established for explosives thresholds and effects on fishes, and in most cases bases interim thresholds upon the lowest level of sound where onset of injury may occur. For effects of explosives on fish, we used the mortality criteria provided in the 2014 ANSI Guidelines (Popper et al. 2014). Based on these guidelines, the peak pressure mortality threshold of 229 dB re 1 μ Pa is applied for fish with and without swim bladders. The 2014 ANSI Technical Report did not suggest numeric thresholds for fish injury or TTS due to explosives (only mortality).

For AFTT Phase III (and other Navy Phase III consultations) we used the impact pile driving and airgun injury thresholds suggested by the ANSI Technical Report as a surrogate for explosives. However, for this consultation we have revised that threshold based on new information from studies on the effects of explosives on fish.

Dahl et al. (2020) reported the effects of underwater explosions on Pacific sardines (*Sardinops sagax*), a species with a physostomous swim bladder (i.e., an open swim bladder with direct connection to the gut via pneumatic duct). Necropsies following explosions observed significant injuries, including fat hematoma, kidney rupture, swim bladder rupture, and reproductive blood vessel rupture. While most significant injuries were consistently present at close range (<50 m), there were inconsistent findings at the 50 to 154 m range (e.g., higher rates of injury were shown at a distance of 154 m compared to 68 m). The acoustic analysis led to the suggestion that, at a range of 154 m, the greater rate of pressure change and deeper low-pressure point during the decompression phase were linked to swim bladder expansion damage and rupture. This includes damage to immediately neighboring organs as manifested by kidney data that are highly correlated with swim bladder data. This is the proposed cause of the observed higher injury rate at 154 m despite the higher peak pressures observed at 68 m, and has been suggested by earlier models of swim bladder related injury (Goertner, 1978 and Wiley et al., 1981 as cited in Dahl et al. 2020).

Jenkins et al. (2022) studied the physical effects on non-auditory tissues of Pacific mackerel (*Scomber japonicus*), another hearing generalist, exposed to sound from underwater explosions. Primary effects were damage to the swim bladder and kidney that exceeded control levels at ≤ 333 m from the explosion (peak sound pressure level 226 dB re 1 μ Pa, SEL 196 dB re 1 μ Pa² s, pressure impulse 98 Pa s). A proportion of fish were dead upon retrieval at 26–40 min post exposure in 6 of 12 cages located ≤ 157 m from the explosion. All fish that died within this period suffered severe injuries, especially swim bladder and kidney rupture. The authors note that fish size was not important in determining susceptibility to injury and that peak pressure and SEL were better predictors of injury than was pressure impulse. In a related study, Smith et al. (2022b) looked at the physical effects on the inner ear of Pacific mackerel exposed to sound from underwater explosions (i.e., a single detonation of 4.5 kg of C4 explosives). Hair cell ciliary

bundles counts were significantly reduced in fish exposed to the explosion as compared to the controls. The extent of effect also varied in animals at different distances from the explosion, with damage occurring in fish as far away as 400 m. Smith et al. (2022a) observed physical damage in the inner ear of Pacific mackerel, exposed to underwater explosions starting at received peak to peak SPLs of 220 dB re 1 μ Pa.

Bowman et al. (2024) placed caged Pacific mackerel at targeted ranges of 150 to 800 m from an explosive source. Animals were left at depth for about three hours post-exposure to determine immediate effects on survival. Fish were then retrieved and assessed for physical damage. They found that peak acoustic pressure levels that produced consistently high injury rates were about 230 dB re μ Pa (Figure 63), which were in effect at ranges from the source of less than about 200 m (Bowman et al. 2024). In contrast, the peak levels for seismic sources are generally smaller, being, for example, approximately 214 dB re μ Pa at range 50 m (Vereide et al. 2023). These results suggest that using pile driving or airgun injury threshold data as a surrogate for explosive thresholds may overestimate impacts to fish. While the type and severity of non-ear injuries reported during simulated impact pile driving studies are similar to those reported in explosive experiments, Bowman et al. (2024) note that caution must be taken in comparing results between effects of pile driving and explosions for several reasons. First, it must be noted that effects from explosions are from a single blast, whereas effects from pile driving come from the exposure to multiple strikes over minutes or hours. Second, there are significant and substantial differences in the characteristics of the pulses between pile driving and explosions, and these may result in very different effects on the swim bladder and how it interacts with surrounding tissues (Bowman et al. 2024).

From Bowman et al. (2024), as shown in Figure 63, injury rates for “any injury” do not approach 50% until around 220 dB re μ Pa. Data from other recent explosive exposure studies also show reported rates of injury significantly different than controls starting at peak sound pressure levels of around 226 dB (Dahl et al. 2020; Jenkins et al. 2022; Jenkins et al. 2023). Therefore, based on the best available information, we apply a peak pressure fish injury threshold of 220 dB for our acoustic effects analysis for this consultation.

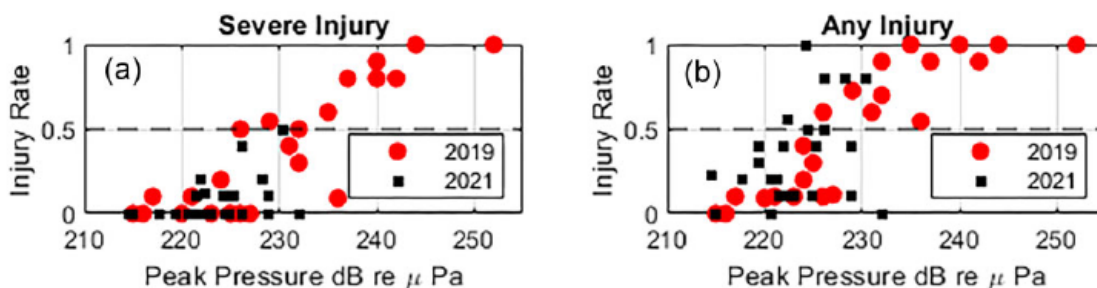


Figure 63. Injury Rates for Severe Injury (a) and Any Injury (b) of Pacific Mackerel Exposed to Explosive Detonations at Varying Sound Pressure Levels (Bowman et al. 2024)

Figure 63 notes: Data represents 10 individual trial days (5 per year), using approximately 10 fish per cage across 50 cages ($n = 501$ fish). Points represent the mean injury response within each treatment cage. The dashed, horizontal lines denote the 50% injury rate.

Though there are no direct measurements of TTS in fishes exposed to explosive sources, it is assumed that fish would demonstrate similar effects on auditory detection as those exposed to other impulsive sources such as those described above. These received sound levels likely represent thresholds at which hearing effects may occur. Auditory injury 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. 2014). The lowest SEL at which TTS has been observed in fishes with hearing specializations exposed to air gun signals is 186 dB re 1 $\mu\text{Pa}^2\text{s}$. As reviewed in the *ANSI Sound Exposure Guideline* technical report (Popper et al. 2014), hearing generalists would be less susceptible to TTS than specialists, even at higher levels and longer durations. Therefore, for the ESA-listed fish with swim bladders (i.e., sturgeon and salmon), we anticipate that TTS would occur at received levels above 186 dB. Consistent with the recommendations in the guidelines, fishes without a swim bladder (i.e., sharks, rays, and sawfish) would not be susceptible to TTS and therefore no criteria are proposed.

In addition to sound pressure levels, we also considered effects from particle motion of fish. Fishes with swim bladders within the action area such as salmonids have a swim bladder that is distant from the ear and does not contribute to sound pressure reception. These fishes are primarily particle motion detectors. Particle motion is the back and forth motion of the component particles of the medium, measured as the particle displacement, velocity, or acceleration. While it is clear that the use of particle motion for establishing criteria is something that should be done in the future, the lack of data on how particle motion impacts fishes as well as the lack of easily used methods to measure particle motion currently precludes the evaluation of particle motion in our acoustic effects analysis (Hawkins et al. 2020).

Activities using explosives would be conducted as described in Section 2 (Description of Proposed Action). Explosive activities would occur in the following locations according to Appendix A (Activity Descriptions) of the AFTT Supplemental EIS/OEIS:

- Gulf Range Complex
- JAX Range Complex
- Key West Range Complex
- Key West Range Complex Inshore
- Northeast Range Complex
- Naval Station Mayport
- Naval Submarine Base New London
- Naval Surface Warfare Center Panama City Testing Range

- Naval Undersea Warfare Center Newport Testing Range
- Port Canaveral, FL
- VACAPES Range Complex
- VACAPES Range Complex Inshore

Most activities involving in-water explosives associated with large caliber naval gunfire, or the launching of targets, missiles, bombs, or other munitions, are conducted more than 12 NM from shore. Generally, large explosives (i.e., bin E6 or greater), which is ordnance with a NEW greater than 10 to 20 lb., are used less often throughout AFTT compared to smaller detonations. Sinking Exercises are conducted greater than 50 NM from shore. The Action Proponents have proposed to conduct ship shock trials only within established ship shock trial boxes (see Figure 4) within the Gulf of America and overlapping the JAX OPAREA, greater than 12 NM from shore. Small ship shock trials could take place within the JAX Range Complex during the spring, summer or fall and during any season within the Gulf of America.

Certain activities with explosives may be conducted closer to shore at locations identified in the proposed action (Section 2), including the training activity mine neutralization explosive ordnance disposal and testing activities semi-stationary equipment testing and line charge testing. In-water explosive activities occur in areas located away from popular recreational dive sites, and most explosive events are conducted during daylight hours. However, there are far fewer detonations conducted in these inshore locations compared to the offshore portions of the Study Area, all of which would utilize explosives categorized as bin E5 (> 5 to 10 lb. NEW) or below. Note, the Action Proponents will implement mitigation measures to avoid impacts from explosive military readiness activities on shallow-water coral reefs, artificial reefs, live hard bottom, submerged aquatic vegetation, and shipwrecks throughout the Study Area (see the Section 2.3, *Standard Operating Procedures and Mitigation Measures*, for details), which consequently, will help avoid potential impacts on fishes that shelter and feed within those habitats. In addition, for AFTT Phase IV, hammerhead sharks and manta rays have been added to the activity-based mitigation measure for explosive mine neutralization events involving Navy divers (described in Section 2.3.2, Table 6), which may further reduce the number and severity of exposures to AFTT explosive stressors for these species.

Exposure Analysis

The introduction of explosive energy into marine environments through military readiness activities presents significant risks to ESA-listed fish species. Understanding these impacts requires careful examination of both the nature of explosive exposure and the biological responses of different fish species. This analysis draws from recent assessments to provide an updated understanding of explosive effects on protected marine species.

NMFS identifies explosive exposure as the most significant risk factor for injury and mortality among ESA-listed fishes in the AFTT action area. This determination stems from the extensive range of potential impacts, which include direct mortality, non-lethal injury, temporary hearing

loss, physiological stress, acoustic masking, and various behavioral modifications. The severity of these effects varies based on multiple factors, including the explosive characteristics, environmental conditions, and the physiological attributes of exposed species (Morin 2024).

Fish responses to explosive exposure vary significantly based on several key biological factors. Species with different hearing specializations and swim bladder configurations demonstrate varying levels of susceptibility to explosive effects. The presence and type of swim bladder plays a particularly crucial role in determining sensitivity to explosive pressure waves, as these organs can amplify the effects of underwater explosions on surrounding tissues. Additionally, the fish's proximity to the explosion source and its position in the water column significantly influence the potential for injury or mortality.

Fish species demonstrate varying levels of susceptibility to explosive impacts based primarily on their anatomical features. The 2014 ANSI Guidelines establish distinct categories for assessment, recognizing that different fish species respond differently to explosive exposure. These categories include fish with no swim bladder, fish with swim bladders not involved in hearing, and fish with swim bladders involved in hearing (Popper et al. 2014). This classification system acknowledges that species with swim bladders are particularly vulnerable to barotrauma and sudden pressure changes from impulsive sounds, which can result in immediate or delayed mortality (Popper et al. 2014).

Beyond immediate physical trauma, fish exhibit various physiological stress responses to explosive exposure. These responses can include changes in swimming behavior, altered metabolic rates, and disrupted sensory functions. The detection and analysis of sound play a crucial role in fish survival, affecting their ability to locate prey, avoid predators, and communicate with conspecifics. Exposure to explosive sounds can significantly impair these essential functions, leading to both immediate and long-term effects on survival and reproductive success.

Density data for ESA-listed fish species within the action area are not currently available. Therefore, it is not possible to estimate the total number of individual fish that may be affected by activities using explosives. In order to estimate the longest range at which a fish may be killed instantaneously, mortally injured, or sustain recoverable injury and TTS, depends on fish size and location in the water column (i.e. depth), and geometry of exposure.

All ESA-listed fishes that may be present in the action area are capable of detecting sound produced by explosions. The Navy calculated ranges to effects for fish species based upon the explosive criteria discussed above. Fishes within these ranges would be predicted to receive the associated effect. Ranges may vary greatly depending on factors such as the cluster size of the explosives, location, depth, and season of the activity. Based on NAEMO calculations, explosive ranges to effects for ESA-listed fishes without a swim bladder (i.e., giant manta ray, oceanic whitetip sharks, scalloped hammerhead sharks, and smalltooth sawfish) and hearing generalists with a swim bladder (Atlantic sturgeon, Gulf sturgeon and Atlantic salmon) are presented in Table 71.

Table 71. Ranges to Effects to Fish from AFTT Explosives by Bin, Hearing Group, Depth, and Cluster Size (Navy 2025b)

Bin E1 (0.1 - 0.25 lb.)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	116 m (6 m)	45 m (6 m)
	>200 m	1	NA	117 m (7 m)	46 m (7 m)
Hearing Generalists	≤200 m	1	< 55 m (8 m)	116 m (6 m)	45 m (6 m)
		25	< 242 m (20 m)	NA	NA
		100	< 451 m (50 m)	NA	NA
	>200 m	1	< 2 m (23 m)	117 m (7 m)	46 m (7 m)
Bin E2 (>0.25 - 0.5 lb.)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	113 m (0 m)	51 m (0 m)
Hearing Generalists		1	< 65 m (0 m)	113 m (0 m)	51 m (0 m)
Bin E3 (>0.5 - 2.5 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	246 m (20 m)	98 m (8 m)
	>200 m	1	NA	253 m (20 m)	100 m (7 m)
Hearing Generalists	≤200 m	1	< 110 m (45 m)	246 m (20 m)	98 m (8 m)
		10	< 300 m (39 m)	NA	NA
	>200 m	1	< 95 m (28 m)	253 m (20 m)	100 m (7 m)

		10	< 260 m (7 m)	NA	NA
Bin E4 (>2.5 - 5 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	440 m (36 m)	159 m (11 m)
	>200 m	1	NA	434 m (36 m)	157 m (12 m)
Hearing Generalists	≤200 m	1	< 304 m (99 m)	440 m (36 m)	159 m (11 m)
	>200 m	1	< 180 m (18 m)	434 m (36 m)	157 m (12 m)
Bin E5 (>5 - 10 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	368 m (31 m)	153 m (10 m)
	>200 m	1	NA	356 m (31 m)	151 m (9 m)
Hearing Generalists	≤200 m	1	< 174 m (171 m)	368 m (31 m)	153 m (10 m)
		8	< 430 m (64 m)	NA	NA
	>200 m	1	< 140 m (7 m)	356 m (31 m)	151 m (9 m)
		4	< 280 m (5 m)	NA	NA
		8	< 370 m (9 m)	NA	NA
Bin E6 (>10 - 20 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	535 m (60 m)	212 m (19 m)
	>200 m	1	NA	551 m (43 m)	213 m (13 m)
Hearing Generalists	≤200 m	1	< 258 m (284 m)	535 m (60 m)	212 m (19 m)

		4	< 449 m (53 m)	NA	NA
	>200 m	1	< 180 m (78 m)	551 m (43 m)	213 m (13 m)
Bin E7 (>20 - 60 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	639 m (59 m)	276 m (14 m)
	>200 m	1	NA	642 m (58 m)	266 m (16 m)
Hearing Generalists	≤200 m	1	< 411 m (58 m)	639 m (59 m)	276 m (14 m)
	>200 m	1	< 406 m (64 m)	642 m (58 m)	266 m (16 m)
Bin E8 (>60 - 100 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	1,065m (122 m)	401 m (39 m)
	>200 m	1	NA	1,064 m (108 m)	396 m (38 m)
Hearing Generalists	≤200 m	1	< 712 m (121 m)	1,065 m (122 m)	401 m (39 m)
	>200 m	1	< 687 m (134 m)	1064 m (108 m)	396 m (38 m)
Bin E9 (>100 - 250 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	824 m (78 m)	392 m (26 m)
	>200 m	1	NA	808 m (80 m)	377 m (30 m)
Hearing Generalists	≤200 m	1	< 504 m (63 m)	824 m (78 m)	392 m (26 m)
	>200 m	1	< 488 m (58 m)	808 m (80 m)	377 m (30 m)

**Biological and Conference Opinion on Navy and Coast Guard
Atlantic Fleet Training and Testing Activities Phase IV**

OPR-2024-02209

Bin E10 (>250 - 500 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	1,135 m (187 m)	461 m (33 m)
	>200 m	1	NA	1,182 m (152 m)	458 m (31 m)
Hearing Generalists	≤200 m	1	< 704 m (235 m)	1,135 m (187 m)	461 m (33 m)
	>200 m	1	< 695 m (119 m)	1,182 m (152 m)	458 m (31 m)
Bin E11 (>500 - 675 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	2,956 m (430 m)	1,082 m (130 m)
	>200 m	1	NA	2,750 m (473 m)	1,085 m (135 m)
Hearing Generalists	≤200 m	1	< 3,500 m (547 m)	2,956 m (430 m)	1,082 m (130 m)
	>200 m	1	< 3,456 m (583 m)	2,750 m (473 m)	1,085 m (135 m)
Bin E12 (>650 - 1,000 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	≤200 m	1	NA	1,318 m (111 m)	563 m (48 m)
	>200 m	1	NA	1,348 m (159 m)	580 m (47 m)
Hearing Generalists	≤200 m	1	< 1,006 m (344 m)	1,318 m (111 m)	563 m (48 m)
	>200 m	1	< 923 m (165 m)	1,348 m (159 m)	580 m (47 m)
Bin E16 (>7,250 - 14,500 lb. NEW)	Depth	Cluster Size	TTS	INJ	MORT
Group					
Fishes without a Swim Bladder	>200 m	1	NA	7,118 m (893 m)	2,583 m (337 m)

Hearing Generalists		1	< 15,681 m (1,456 m)	7,118 m (893 m)	2,583 m (337 m)

Notes: TTS ranges for fishes with a swim bladder only; Median ranges with standard deviation ranges in parentheses; NA = not applicable; < indicates that the range to effects would be less than the provided value

Due to the lack of available density or abundance information for ESA-listed fish species in the portion of the action area where AFTT explosives would be used, we cannot quantify the total number of individual fish from each species that would be exposed to stressors from explosives. As such, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take (i.e., in the form of the number of fish suffering mortality, injury, TTS, and behavioral disruption) or to monitor take-related impacts in terms of individuals of the following ESA-listed fish species: Atlantic salmon – Gulf of Maine DPS, Atlantic sturgeon – Gulf of Maine DPS, Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Gulf sturgeon, giant manta ray, oceanic whitetip shark, scalloped hammerhead shark – Central and Southwest Atlantic DPS, and smalltooth sawfish.

Because it is not practical to express the amount of anticipated take of these fish species, we instead use a surrogate measure to express the amount or extent of incidental take. The surrogate for the incidental take of the ESA-listed fish listed above is based on: 1) the ranges to effects, which are the distances in the water column that correlate with each of the predicted effects (e.g., mortality, injury, TTS) from explosives in those areas occupied by adults of these species, and 2) explosive activity level, which is the total number of explosives (by bin type) that would be detonated in the action area as part of the proposed action.

Response Analysis

Based upon the range to effect calculations for onset of injury to fishes from the sound produced from explosions, fish located within hundreds (most of the charges) to thousands of meters (largest charges) could be injured or killed. In general, the explosives that belong to larger bins (with large NEWs) produce longer ranges within each effect category. For the largest charges, there are usually only one or very few of this type of explosives proposed for use during each seven-year period of AFTT training and testing. Some ranges will also vary depending upon the number of explosions in a single activity, depth and weight of the charge, etc.

The relationship between explosive exposure and fish mortality follows distinct patterns based on several key factors. Fishes without a swim bladder, adult or fully developed fishes, and larger species are assumed to be generally be less susceptible to injury and mortality from explosions compared to small, juvenile or larval fishes (Popper et al. 2014; Navy 2017). A study by Jenkins et al. (2022) suggests that peak pressure and SELs may serve as more reliable predictors of injury severity than fish size or mass. However, the overall size range of the fish in this study may not have varied enough to be able to detect a difference in susceptibility with differing

weight or length. Other factors also influence the degree of sensitivity such as state of buoyancy, proximity to the blast (e.g., depth in the water, bodily alignment), and condition of the fish during the exposure event.

The most immediate and severe physiological responses to explosive exposure occur in fish tissues and organs. Research has shown that swim bladders and kidneys are particularly vulnerable to damage from explosive pressure waves. In controlled studies, fish exposed to underwater explosions exhibited severe injuries to these organs, with damage patterns correlating directly to their proximity to the explosion source. Recent research documented that fish within 333 m of explosive detonations showed significant swim bladder and kidney damage, with peak sound pressure levels reaching 226 dB re 1 μ Pa (Jenkins et al. 2022). These injuries often proved fatal, particularly in cases where fish were located within 157 m of the explosion site.

Explosive detonations can cause extensive damage to non-auditory tissues throughout a fish's body. This damage occurs through multiple mechanisms, including direct pressure effects and indirect trauma from rapid pressure changes. The intense pressure waves generated by underwater explosions can cause immediate tissue damage, particularly in gas-filled organs (Jenkins, 2022). These effects can manifest even at considerable distances from the explosion source, though their severity typically decreases with distance.

For elasmobranch species, to date, no hearing loss has been demonstrated when exposed to other acoustic stressors such as air guns. Rather, the risk of it occurring for these species is much lower than those fish that do possess swim bladders. Therefore, ranges for these species would likely be lower than what is calculated given the fact TTS has not been demonstrated at the thresholds, and the criteria for TTS is already based upon a very conservative value for more sensitive fish species with swim bladders. For fishes with swim bladders, the ESA-listed fish species that may be present in the action area do not have any hearing specializations, and do not have swim bladders involved in hearing. Similar to elasmobranchs, we are unaware of any research demonstrating TTS in these species from explosives. Although TTS has not been demonstrated in these species' groups, this does not mean it does not occur. Because we know it can occur from other acoustic stressors, we assume it is possible from exposure to an explosive sound stressor. If TTS does occur, it would likely co-occur with barotraumas, and therefore would be within the range of other injuries these fishes are likely to experience from blast exposures. Depending on the severity of the TTS and underlying degree of hair cell damage, a fish would be expected to recover from the impairment over a period of weeks (for the worst degree of TTS). Most TTS however, would likely be restored to normal hearing ranges within a few hours or days.

Physiological and behavioral responses of fishes to acoustic stressors have been described in greater detail for other acoustics stressors on fishes. Exposure to explosions could cause spikes in stress hormone levels, or alter a fish's natural behavioral patterns. There are currently no behavioral thresholds for explosives established for fishes. Behavioral responses could be expected to occur within the range to effects for other injurious or physiological responses, and perhaps be extended beyond these ranges if a fish could detect the sound at those greater distances. Given that none of the species considered here have any specialized hearing

adaptations, and the threshold for TTS is considered conservative for these hearing groups, most behavioral responses would be expected to occur within the range to effects for injury, mortality and TTS. These effects, depending on the severity and duration could lead to fitness consequences such as reduced survival, growth, or reproductive capacity. Because sound generated from a detonation is brief, long-term effects on fish behavior are unlikely. Similarly, long periods of masking are unlikely from blast exposure for fishes, although some brief masking periods could also occur if multiple detonations occurred (within a few seconds apart). If multiple exposures occurred within a short period of time, such as over the course of a day or consecutive days, fishes may also choose to avoid the area of disturbance. The Navy's training and testing activities involving explosions are generally dispersed in space and time throughout the large action area, and repeated exposure of individual fishes to sound and energy from in-water explosions over the course of a day or multiple days is not likely. Thus, most physiological stress and behavioral effects are expected to be temporary, of a short duration, and would return to normal quickly after cessation of the blast wave.

6.3.2 Vessel Strikes

The probability of a vessel or USV strike depends on the number, size, and speed of vessels, as well as the distribution, abundance, and behavior of the ESA-listed fish species in the action area. Below we analyze the effects of vessel and USV strike on ESA-listed fish as a result of the proposed action.

More information on Navy and Coast Guard vessel activity in the AFTT action area can be found in Section 2.4.4 (Physical Disturbance and Strike Stressors – Vessels) and in the AFTT Phase IV BA (Navy 2024c). For a more detailed discussion of the general threat of vessel strike to ESA-listed fish in the action area see Section 5.11 (Environmental Baseline: Vessel Strike).

Exposure Analysis

Most fish species face minimal risk from vessel or USV strikes throughout the majority of the action area. For many pelagic fish species, vessel or USV strike risk is considered low due to their ability to both detect and avoid moving objects in the water given their swimming agility and sensory capabilities. Fish possess several natural adaptations that help them avoid vessel strikes. They can detect approaching vessels using multiple sensory mechanisms, including sight, hearing, and their lateral line system. A study on fish 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 fish ahead of a vessel showed avoidance reactions at ranges of 50 to 350 m (160 to 490 ft). When the vessel passed over them, some fish responded with sudden escape responses that movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Although most fish are able to detect and avoid vessels, species that are typically distributed near the surface or high in the water column, as well as large-bodied, slow-moving fishes such manta rays (e.g., Deakos et

al. 2011; Couturier et al. 2012; Braun et al. 2015) and sturgeon (e.g., Brown and Murphy 2010; Couturier et al. 2012), are considered to be at a greater risk of being struck by a vessel or USV compared to other species.

For benthic associated ESA-listed species (i.e., sturgeon), vessel strike risk is extremely low in offshore, deep water areas because these species typically occur in low densities and at depths below the draft depth of even the largest military vessels. ESA-listed fish such as Atlantic sturgeon, smalltooth sawfish, Gulf sturgeon, giant manta ray, and scalloped hammerhead shark may utilize nearshore and inshore portions of the action area, where the vessel strike risk profile changes significantly as these species are likely more vulnerable due to shallow water, confined spaces and increased vessel traffic. In these inshore and nearshore waters of the action area where higher ESA-listed fish abundance of some species makes vessel encounters more likely, Action Proponent vessel use occurs more regularly and is mainly from small, high-speed (greater than 10 knots) vessels. Activities that include vessel movements in the inshore waters of the action area occur on a more regular basis than the offshore activities, and often involve the vessels traveling at speeds greater than 10 knots, and generally in more confined waterways than activities occurring in the offshore waters. Propulsion testing (Section 2.4.4), which can involve vessels operating at speeds in excess of 30 knots, may pose an even greater strike risk of ESA-listed fish strike due to the very high vessel speeds. Nearshore and inshore portions of the action area with the highest risk of vessel or USV strike include the following: Chesapeake Bay, KWRC and SFOMF, Gulf Range Complex and JAX Range Complex Inshore locations (St. Andrews Bay and Port Canaveral) Gulf Range Complex Inshore and Naval Surface Warfare Center Panama City Testing Range within 1 mile of the coast and two pierside locations (New Orleans, LA; Pascagoula, MS) Northeast, VACAPES Range Complex, and Northeast Range Complexes, associated inshore locations, and during pierside activities in four locations (Bath, ME; Portsmouth Naval Shipyard; Boston, MA; Naval Submarine Base New London).

Atlantic Salmon – Gulf of Maine DPS

Atlantic salmon will only potentially encounter vessels and in-water devices during training and testing activities in the Northeast Range Complexes, associated inshore locations, and during pierside activities in four locations (Bath, ME; Portsmouth Naval Shipyard; Boston, MA; Naval Submarine Base New London). Atlantic salmon are fast swimmers, typically occurring in the top 3 m of the water column, while moving through coastal waters (Hedger et al. 2009). Salmon can sense pressure changes in the water column and swim quickly (Baum 1997; Popper and Hastings 2009), and are likely to escape collision with vessels and in-water devices. Therefore, while AFTT vessels and USVs could overlap with the Atlantic salmon Gulf of Maine DPS, we find that a strike of this species as a result of the proposed action is extremely unlikely. It is possible that an Atlantic salmon may experience some level of physical disturbance due to the presence of a vessel or USV, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be insignificant to the animal. Therefore, potential effects on Atlantic salmon Gulf of Maine DPS

from vessels and USV are discountable (in the case of strikes) or insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects.

Smalltooth Sawfish

The occurrence of smalltooth sawfish overlaps with the more southern range complexes and inshore locations of the action area, ranging from the JAX to Gulf Range Complexes. Smalltooth sawfish are large and fast moving predators of shallow flats. Smalltooth sawfish have been observed with propeller injuries, likely caused when vessels drive over shallow areas when sawfish are present with their dorsal fins and upper caudal lobe out of the water or near the surface (NMFS 2018b). However, in general, vessel strike is not considered a significant threat to this species (e.g., it is not mentioned in the species' recovery plan), and we could not find any information on smalltooth sawfish vessel strike related mortalities. Given the small area of overlap between smalltooth sawfish occurrence and AFTT vessels and USVs in the action area, the anticipated low density of this species in those areas, and the lack of information indicating that vessel strike is a significant threat, we find that a smalltooth sawfish strike as a result of the proposed action is extremely unlikely. It is possible that a sawfish may experience some level of physical disturbance due to the presence of a vessel or USV, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be insignificant to the animal. Therefore, potential effects on smalltooth sawfish from vessels and USV are discountable (in the case of strikes) or insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects.

Oceanic Whitetip Shark, Scalloped Hammerhead Shark, and Giant Manta Ray

Each of the ESA-listed elasmobranch species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. Oceanic whitetip sharks can be found at the ocean surface and down to at least 152 m deep, but most frequently stay between depths of 25.5 and 50 m (Carlson and Gulak 2012; Young et al. 2017). Scalloped hammerhead sharks may occur in the upper portions of the water column as well. Despite these species' utilization of the upper portion of the water column for at least some of their life history, in most cases, we would anticipate these ESA-listed elasmobranchs would be able to detect vessels or other in-water devices and avoid them. Sharks and rays are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). Manta rays are presumed to be susceptible to vessel and USV strikes due primarily to their large size, slow swimming speed, and distribution in the upper portion of the water column (Miller 2017). The NMFS 2017 giant manta ray status review (Miller 2017) identified boat strikes as a "low risk" threat to this species, although the confidence in this rating was also low due to the lack of available information.

Given the low abundance of ESA-listed elasmobranch species in the action area (particularly around military ports or installations where vessel traffic will be the greatest), the ability of these species to maneuver to avoid any oncoming vessels, and the lack of documented cases of Navy

or Coast Guard vessels or USVs striking these species (or any other fish species), it is extremely unlikely that a vessel or USV associated with AFTT activities will strike an ESA-listed elasmobranch species.

It is possible that fish may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be insignificant to the animal. Any behavioral or stress response from fish avoiding an oncoming vessel or in-water device would be short-term, temporary and have no lasting impact of individual fitness. Therefore, potential effects on giant manta ray, oceanic whitetip shark, and Central and Southwest Atlantic DPS scalloped hammerhead shark from vessels and USV are discountable (in the case of strikes) or insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects.

Atlantic Sturgeon

Vessel strike has been identified as one of the major threats to ESA-listed Atlantic sturgeon populations, and new information suggests that vessel strikes of this species occur more frequently and in more areas than what NMFS anticipated when the DPSs were first listed. All five DPSs of Atlantic sturgeon may be exposed to AFTT activities that could result in vessel strike. The five DPSs of Atlantic sturgeon frequent the coastal shelf waters along the Atlantic Ocean and return to their natal rivers to spawn. Therefore, they have the potential to encounter Action Proponent vessels and USVs over a large portion of the action area, spanning waters from the continental shelf of Canada to the northeastern coast of Florida. This includes many inshore areas where AFTT activities are conducted. Atlantic sturgeon have been documented to be susceptible to vessel strikes, particularly in estuarine and riverine environments where the waters are shallower and more restricted. In these locations, the strikes could occur at or near the surface or bottom. The data by Watterson et al. (2017) indicate sturgeon spend a high percentage of time in bays and estuaries less than 15 m deep, which would increase their risk of vessel strikes during periods of co-occurrence with AFTT activities. Coupled with known research indicating an increased sturgeon presence during certain times of year, narrow widths and channel depths of navigation channels, and somewhat confined areas in bays and estuaries, results in an increased potential for sturgeon and vessel and USV encounters. Once these fish moved into estuarine and riverine environments, they occurred closer to the surface. In the Chesapeake Bay, as many as 53% of detections occurred in water shallower than 15 m, and 9% occurred in waters less than 10 m in depth. In riverine systems, such as the York River, a much larger percentage of the time is spent at shallower depths; 65% of the detections of sturgeon occurred in waters less than 10 m in depth and as much as 30% occurred in depths less than 5 m (Navy 2017).

When sturgeon are located offshore in oceanic portions of the action area, they are unlikely to encounter AFTT vessels or USVs because the fish are likely located at depths greater than 15 m (e.g., Watterson et al. 2017), and below the draft depth of even the largest military vessels (Nimitz-class aircraft carriers have a draft of 41 ft (12.5 m)). Plus, considering best available information, including recent research (e.g., Watterson et al. 2017), it would be an uncommon occurrence for an Atlantic sturgeon to encounter AFTT vessels or USVs in deeper offshore waters of the action area due to the large area over which AFTT activities are conducted and the

anticipated low densities of sturgeon throughout most of the action area. Therefore, while vessel or USV strikes of Atlantic sturgeon in offshore waters of the action area are possible, the likelihood of this occurring is so low as to be discountable (Watterson et al. 2017).

Multiple studies have shown that Atlantic sturgeon may not move away from vessels or avoid areas with vessel activity (Reine et al. 2014; Balazik et al. 2017a; Barber 2017; DiJohnson 2019; Balazik et al. 2020). DiJohnson (2019) investigated the influence of vessels on Atlantic sturgeon movement and found no evidence that Atlantic sturgeon behavior is affected by commercial shipping, but is more influenced by sediment type. Examination of the salvaged carcasses suggest that most fatalities are the result of the sturgeon being struck by a large vessel causing either blunt trauma injuries (e.g., broken scutes, bruising, damaged soft tissues) or propeller injuries (e.g., decapitation, complete transection of other parts of the sturgeon body, or deep slices nearly through the body depth of large sturgeon) (Balazik et al. 2012b). Sturgeon located on or near the seafloor are more susceptible to lethal vessel strike from larger vessels with bigger propellers and a larger draft (i.e., the depth of the vessel below the waterline). In most instances, a small surface vessel or USV will not present a strike risk to sturgeon located on the seafloor. A study in the James River, Virginia tracked the movement of three Atlantic sturgeon implanted with acoustic transmitters found that the fish occurred in water depths overlapping with the draft of ocean cargo vessels in about 7 m, but were rarely in depths overlapping the draft of tugboats and small recreational craft in 1-2 m (Balazik et al. 2012b). The three fish were detected in the navigation channel of the river 69% of the time (Balazik et al. 2012b), which supports the notion that rivers with narrow channels and large-vessel traffic have high incidences of vessel strikes on adult Atlantic sturgeon (ASSRT 2007). While sturgeon occasionally occur closer to the surface and could be susceptible to strike from a smaller vessel, in most instances such strikes would not be lethal, as evidenced by live sturgeon found with small nicks and cuts likely caused by smaller vessel propellers.

The frequency of large vessel traffic in inshore environments and in and around military ports presents a higher risk of an Atlantic sturgeon being struck over time. Inshore training activities involving vessel movements on the Atlantic Coast primarily occur in the following locations that coincide with the distribution of Atlantic sturgeon: (1) Northeast Range Complexes Inshore; (2) VACAPES Range Complex Inshore; and (3) JAX Range Complex Inshore (Navy 2024c). The Navy conducts many training and testing activities in inshore waters, many of which involve high speed (greater than 10 knots) vessel movements and maneuvering (Navy 2024c).

High speed vessel maneuvers further increase the potential risk of vessel strikes by reducing the available reaction time of both the fish and vessel operator to an impending strike. However, nearly all of the high speed vessel movements are conducted by small support craft with drafts less than 10 ft (3 m) and only 2% of the detections of sturgeon within the lower Chesapeake Bay, and none at the mouth of the James River, occurred in waters less than 5 m of the surface. This indicates strikes on sturgeon by small vessels operating in the bay or near river mouths are much less likely to occur since sturgeon are likely to be located deeper, and beyond the draft of the

smaller vessels. Atlantic sturgeon may be susceptible to strike from small vessels when they are in the upper reaches of river systems in very shallow water but we have no additional information on the risk of this occurring.

Even though ship strikes overall are a huge cause of mortality to the Atlantic sturgeon, different populations in different regions feel the effects of this threat differently. The occurrence and prevalence of Atlantic sturgeon ship strikes in the VACAPES Range Complex Inshore has been documented (Balazik et al., 2012b; Balazik, 2016). A large spawning population of Atlantic sturgeon exists in the James River, a Virginia river that flows into the Chesapeake Bay (Balazik, 2012; Balazik et al., 2012a) and Navy-funded research identified a small spawning population in one of the tributaries of the York River in 2013 (Hager et al., 2014; Kahn et al., 2014). More than 100 Atlantic sturgeon carcasses have been salvaged in the James River from 2007-2018, and additional carcasses were reported but could not be salvaged (Greenlee et al. 2017). Many of the salvaged carcasses had evidence of a fatal vessel strike. Data from the Navy's acoustic telemetry array in the Chesapeake Bay has shown that Atlantic sturgeon from all five DPSs have been observed in the Chesapeake Bay (Hager 2016) Kazyak et al. (2021).

According to the New York Bight DPS of Atlantic Sturgeon 5-Year Review, vessel strikes were considered a primary threat when NMFS listed the DPS as endangered. In New York's Hudson River from the period of 2009-2015 there were 106 reported sturgeon mortalities associated with vessel strikes. The New York Department of Environmental Conservation reported that at least 17 dead Atlantic sturgeon with vessel strike injuries were found in the Hudson River in 2019, of which at least 10 were adults (NMFS 2022a). In addition, vessel struck Atlantic sturgeon have been found in other parts of the New York Bight DPS's range including the Merrimack, Thames, and Nanticoke river estuaries based on NMFS Sturgeon Salvage Permit Reporting data.

In the Delaware Bay and River, Brown and Murphy (2010), reported 28 deaths of sturgeon, with 50% attributed to vessel strikes between 2005 and 2008. It is worth noting that the study included an unknown number of additional sturgeon mortalities that were likely struck by vessels, but not included in the total attributed to vessel strikes because the bodies were too decomposed to accurately determine the cause of death. Fox et al. (2020) estimated that a total of 199 and 213 Atlantic sturgeon carcasses from vessel strike were present along the Delaware Estuary shoreline in 2018 and 2019, respectively.

The Action Proponents conduct a number of training exercises in the Narragansett Bay, Rhode Island each year. However, there is very little vessel strike data for this area. While it may be that Atlantic sturgeon are located in deeper waters and not subject to strikes, there is very little information on the occurrence of Atlantic sturgeon in Narragansett Bay or the depth range they inhabit while there. Should sturgeon occur in the bay and be shallow enough in the water column, there is a chance that a strike could result from AFTT activities.

We do not currently have vessel strike information for Atlantic sturgeon in the Cooper River, South Carolina, although the Navy conducts training exercises in the Cooper River. While information is not available regarding the depths at which sturgeon occur in the Cooper River,

we assume it is similar to the York River. Therefore, there may be potential for vessel strikes of Atlantic sturgeon there as well.

For the St. Johns River in Florida, the Navy also funded research for over a two-year period in cooperation with the University of Georgia. The researchers established a telemetry receiver array in the river (Fox et al. 2016) and collected telemetry data from sturgeon captured and tagged. These efforts yielded only a single fish capture, which was tagged. Based on genetic analysis, this fish was not a native to the St. Johns River, but originally from the Altamaha River in Georgia. Eight other Atlantic sturgeon were also only briefly detected in the array during the course of the study during the winter and early spring months (Fox et al. 2016). Based on these survey results, the low potential of sturgeon to be present in the St. Johns River makes vessel strikes in this area very unlikely.

Vessel strikes were considered a threat to the Gulf of Maine DPS when NMFS listed the DPS as threatened. However, NMFS did not consider it a primary threat to the DPS because the risk appeared to be less than that of the New York Bight and Chesapeake Bay DPSs based on the limited number of known vessel struck carcasses in Gulf of Maine rivers and given differences in vessel presence, particularly of large vessels, in the DPS's natal river.

Several studies have noted that reporting of deceased Atlantic sturgeon is likely not representative of all of the cases of vessel strike that occurs; therefore, the actual rate of lethal vessel strike is underestimated (Brown and Murphy 2010; Balazik et al. 2012b; Fox et al. 2020). The Balazik et al. (2012a) study of Atlantic sturgeon on the James River, VA, estimated that 31% (5 out of 16) deceased sturgeon released in the river were eventually reported. However, the carcass reporting rate from the Balazik et al. (2012a) study likely underestimated the number of unobserved mortalities. We base this on the following: the study occurred over a short time (approximately 4 weeks) in a single year, the sample size was small (16 deployments), and the researchers were actively searching for the carcasses, which is different from opportunistic sightings and receiving reports from the public.

A newer study by Fox et al. (2020) from Delaware State University in partnership with the USFWS and Delaware Natural Resources, estimated Atlantic sturgeon carcass reporting rates for the Delaware River and Estuary. A total of 168 carcasses were released for the study seasonally over two years, providing a greater sample size and temporal distribution than previous studies. Additionally, Fox et al. (2020) relied on multiple sources of reporting and was not based on researchers actively searching for the carcasses. Estimated reporting rates varied from 2.0% (spring 2018) to 12.5% (summer and fall 2018) with a reporting rate of 4.76% when they combined the data for all seasons over the two years (2018 and 2019) of the study. Because this is the best available information, we use the 4.76% Atlantic sturgeon carcass reporting rate to adjust the annual average reports of dead Atlantic sturgeon attributed to vessel strike.

The Sturgeon Salvage Program²⁶ is a network run by NMFS to help conserve Atlantic and shortnose sturgeon. Information regarding deceased sturgeon that wash up on riverbanks and ocean beaches is sent to NMFS through this network. Using data from the reports received through the Sturgeon Salvage Program network, we estimated Atlantic sturgeon vessel strike that could occur from the AFTT vessel transits. Sturgeon Salvage Program data from 2021-2024 shows that 113 (out of 218 total) records of reported and salvaged sturgeon can conservatively be attributed to vessel strike along the Atlantic coast. This averages to 28 salvaged sturgeon per year over the four years of recent data attained. Applying the 4.76% Atlantic sturgeon carcass reporting rate from above yields a total estimate of 588 vessel strikes per year from all vessels along the Atlantic coast.

Action Proponent vessels and USVs represent about 1% of overall vessel traffic throughout the entire AFTT action area (Navy 2025a). We recognize that the proportion of AFTT vessel and USV activity, relative to all vessel activity, varies widely depending on the specific location within the action area. Near large military port facilities (e.g., Naval Station Norfolk or Naval Station Mayport) we expect AFTT vessel and USV activity to account for a higher proportion of total vessel traffic, whereas in others areas (e.g., busy commercial ports and shipping lanes) AFTT vessel and USV activity likely accounts for a lower than average proportion of total vessel traffic. However, we do not have more detailed spatial information regarding the proportion that AFTT vessel and USV activity makes up of all vessel activity within specific areas, particularly within the inshore, shallow water areas where there is a greater risk of Atlantic sturgeon vessel strike. In addition, records of salvaged sturgeon with signs of vessel strike only provide information on where the carcass was found but do not indicate the location of where the strike occurred. Lacking the available information to do a more spatially refined quantitative analysis of Atlantic sturgeon vessel strike, we instead estimate the number of strikes resulting from the proposed action along the entire Atlantic Coast.

Therefore, we apply the 1% estimate of overall vessel traffic throughout the entire AFTT action area (Navy 2025a) to our annual strike estimate from all vessels above. We calculate the number of Atlantic sturgeon vessel strikes resulting from the proposed action as follows:

$588 \text{ [vessel strikes in action area annually from all vessels]} * .01 \text{ [proportion of Navy and Coast Guard vessel traffic in the action area]} = 5.9$

Based on the information provided by the Action Proponents, published research and supplemental salvage data, we anticipate 5.9 Atlantic sturgeon vessel or USV strikes annually as a result of the proposed action.

Next, we estimated the proportion of the total vessel strikes resulting from the proposed action attributed to each of the ESA-listed Atlantic sturgeon DPSs. Kazyak et al. (2021) conducted a genetic mixed stock analysis of 1,704 Atlantic sturgeon encountered across the U.S. Atlantic

²⁶ <https://www.fisheries.noaa.gov/new-england-mid-atlantic/endangered-species-conservation/report-stranded-injured-or-dead-sturgeon>

Coast that can be used to attribute portions of the coastwide vessel strikes estimate to each of the five DPSs. The majority of the total estimates are for the New York Bight DPS, which includes sturgeon from the Hudson River, NY, and the Delaware River, DE. Kazyak et al. (2021) provided Atlantic sturgeon stock composition proportions for three Atlantic Coast regions: NORTH – defined as the area North of Cape Cod, Massachusetts; MID – defined as the area south of Cape Cod and north of Cape Hatteras, North Carolina; and SOUTH – defined as the area south of Cape Hatteras. Since we do not have more detailed spatial information on Action Proponent vessel and USV activity to determine the relative strike risk at different locations throughout the action area, we proportioned our estimated annual Atlantic sturgeon vessel or USV strikes (i.e., 5.9) by region (i.e., NORTH, MID, and SOUTH from Kazyak et al.) based on Sturgeon Salvage Program data. The 113 records in the Sturgeon Salvage Program database from 2021-2024 that we determined were likely vessel strike caused mortalities were proportioned by region as follows: NORTH 2.7% (3 records); MID 79.6% (90 records), and SOUTH 17.7% (20 records). Applying these proportions to our estimated annual Atlantic sturgeon vessel or USV strikes (i.e., 5.9) yields the following annual strikes per region: NORTH 0.16, MID 4.70, and SOUTH 1.04. Next, to proportion the estimated strikes in each region by DPS, we multiply the estimated annual Atlantic sturgeon strikes per region by the DPS proportional distributions in that region, based on Kazyak et al. 2021 (Table 72). The total estimated annual and 7-year number of vessel or USV strikes as a result of the proposed action are shown for each of the five Atlantic sturgeon DPSs in Table 72.

Gulf Sturgeon

Gulf sturgeon occurrence overlaps with vessel and USV use during training and testing activities throughout the continental shelf waters of the northern Gulf of America, especially in the Panama City and Pensacola OPAREAs, the Naval Surface Warfare Center Panama City Testing Range, and St. Andrew Bay. There are little data available on vessel strikes of Gulf sturgeon. However, because of the similarity of these species and the lack of data specific to Gulf sturgeon, we assume many of the same reasons Atlantic sturgeon are susceptible to vessel strike, Gulf sturgeon would also be at risk. The NMFS 2022 Status Review of this species (NMFS 2009b; Heublein and Kaeser 2022) indicated that vessel strikes may be an emerging threat to Gulf sturgeon.

While not nearly as susceptible as Atlantic sturgeon based on documented strandings, some Gulf sturgeon vessel strikes have been reported. The regular jumping and breaching behavior of gulf sturgeon also puts them at risk of strikes by large vessels at the water surface. To date, there have been five documented Gulf Sturgeon mortalities that exhibited evidence of a collision with large vessels (Heublein and Kaeser 2022). This may be a result of low rates of Gulf Sturgeon ship strikes, or low rates of reporting where ship strikes are occurring. The threat of ship strikes may increase in areas of the northern Gulf of America where barge and tug boat traffic associated with coastal protection, restoration, and infrastructure activities is expected to increase.

Table 72. Atlantic Sturgeon DPS Proportional Distributions by Region (based on Kazyak et al. 2021), and Estimated Vessel or USV Strikes by DPS as a Result of the Proposed Action

Atlantic sturgeon DPS	NORTH DPS % (Kazyak et al. 2021)	MID DPS % (Kazyak et al. 2021)	SOUTH DPS % (Kazyak et al. 2021)	NORTH Annual Strikes (0.16 * DPS %)	MID Annual Strikes (4.70 * DPS %)	SOUTH Annual Strikes (1.04 * DPS %)	Total Annual Strikes for DPS	Total 7-Year Strikes for DPS
New York Bight	0%	55%	0%	0	2.59	0	2.59	18.1
Chesapeake Bay	0%	23%	3%	0	1.08	0.03	1.11	7.7
South Atlantic	0%	14%	91%	0	0.66	0.95	1.61	11.3
Carolina	0%	6%	6%	0	0.28	0.06	0.34	2.4
Gulf of Maine	88%*	2%	0%	0.14	0.09	0	0.23	1.6

* The remaining 12.2% of the NORTH fish were assigned to Canadian River populations that are not ESA-listed (Kazyak et al. 2021). Therefore, we did not calculate these strikes in our exposure analysis.

Information on recorded Gulf sturgeon vessel strike incidents is lacking. Based on information provided in the latest NMFS species status review (Heublein and Kaeser 2022), on average, less than one such incident is recorded annually. For purposes of our analysis, we use an average of one reported Gulf sturgeon vessel strike per year as a reasonable estimate based on the available information. As discussed above for Atlantic sturgeon carcass reporting rates, this is an underestimate of actual Gulf sturgeon deaths by vessel strike because many are unreported or sink to the bottom and are not observed. Similarly, we use the 4.76% carcass reporting rate from Fox et al. (2020) to adjust the annual average reports of dead Gulf sturgeon attributed to vessel strike as follows: $1.0 / 0.0476 = 21.0$.

Based on information provided by the Action Proponents, we assume Navy and Coast Guard vessels and USVs could account for up to 1% of vessel traffic in the Gulf of America (Navy 2025a), including the inshore, shallow water portions of the action area where Gulf sturgeon are more susceptible to vessel or USV strike. As discussed above in our Atlantic sturgeon vessel strike analysis, the proportion of AFTT vessel and USV activity, relative to all vessel activity, varies widely depending on the specific location within the Gulf of America portion of action area. However, as discussed above, since we do not have the available information to do a more spatially refined quantitative analysis of Gulf sturgeon vessel strike, we instead estimate the number of strikes resulting from the proposed action throughout the Gulf of America portion of the action area.

Therefore, we apply the 1% estimate of overall vessel traffic throughout the entire AFTT action area (Navy 2025a) to our annual Gulf sturgeon strike estimate, from all vessels, above. We calculate the number of Gulf sturgeon vessel strikes resulting from the proposed action as follows:

$21.0 \text{ [vessel strikes in action area annually from all vessels]} * .01 \text{ [proportion of Navy and Coast Guard vessel traffic in the action area]} = 0.21$

Based on the information provided by the Action Proponents, published research and supplemental salvage data, we anticipate 0.21 Gulf sturgeon vessel or USV strikes annually, and 1.47 strikes every seven years, as a result of the proposed action.

Response Analysis

If an individual sturgeon does not sustain a lethal injury from vessel strike, there would be an energetic cost associated with the time it takes to recover from a wound, and reduced individual fitness for the duration it takes to recover. However, due to the nature of vessel strikes on sturgeon, and the likely size of the AFTT vessels or USVs associated with such strikes (i.e., large vessels with powerful propellers and drafts deep enough to strike sturgeon at or near the seafloor), we assume all vessel strikes of Atlantic and Gulf sturgeon as a result of the proposed action will result in mortality or serious injury leading to mortality.

6.4 Invertebrates

6.4.1 Acoustic Effects Analysis

The increasing presence of anthropogenic noise in marine environments necessitates careful examination of its effects on protected species. Recent scientific investigations have revealed complex patterns of response to acoustic stimuli, though direct studies on these specific protected species remain limited. This analysis examines the current scientific evidence regarding acoustic stressors' (i.e., sonar and other transducers) effects on ESA-listed invertebrates, with a particular focus on coral species and queen conch within designated AFTT study areas.

Corals

Most marine invertebrates, including corals and mollusks, possess specialized mechanisms for detecting acoustic stimuli that differ fundamentally from those of vertebrates. Rather than responding primarily to sound pressure, invertebrates are mainly sensitive to particle motion, particularly when they live close to the seabed where substrate vibration plays a significant role (Solé et al. 2023). This detection occurs through various specialized organs, including ciliated hair cells and statocysts, which allow these organisms to sense local water movements and maintain equilibrium (Solé et al. 2023). The detection range is typically limited, as particle motion diminishes rapidly with distance from the sound source, making the impact of noise highly dependent on proximity to its source. This understanding is crucial for evaluating potential impacts of military training and testing activities involving acoustic stressors.

ESA-listed corals possess relatively simple but effective mechanisms for detecting environmental stimuli. The sensory capabilities of adult corals are primarily limited to detecting water movement using receptors on their tentacles, while coral larvae utilize exterior cilia to detect nearby water movements (Pysanczyn et al. 2023). This biological framework suggests that these species' ability to sense acoustic signals is confined to detecting particle motion rather than pressure waves, with effective detection limited to very short distances from sound sources.

Research has demonstrated that coral larvae exhibit measurable responses to acoustic cues, particularly in relation to settlement behavior. Studies have shown that coral larvae can respond to reef sounds during their settlement phase, with specific sensitivity to low-frequency sounds between 25 and 1,000 Hz. For instance, mountainous star coral larvae demonstrated orientation toward reef sound playbacks at received sound levels of approximately 145 to 149 dB re 1 μ Pa, though this response was only observed when speakers were located within 1 to 2 m of the larvae (Pysanczyn et al. 2023).

Queen Conch

Despite queen conch's ecological and commercial importance in the Caribbean region, direct studies of their acoustic sensitivity and responses to anthropogenic noise are notably sparse in the scientific literature (Horn et al. 2022). As a gastropod mollusk, queen conch likely shares some sensory mechanisms with other studied species in this group, but specific research on their responses to military training activities or other anthropogenic noise sources is currently limited (Horn et al. 2022).

The acoustic effects of military training and testing activities on these species must be considered within the context of their natural sensory capabilities and habitat distribution. Most military sonar operations occur seaward of the coastal zone, maintaining significant distance from primary coral and queen conch habitats. When operations do occur near these habitats, exposure would need to be extremely close to trigger particle motion sufficient to elicit a response (Pysanczyn et al. 2023). This spatial separation, combined with the species' limited acoustic sensitivity range, naturally minimizes potential impacts.

Summary of Acoustic Impacts to Invertebrates

The Navy's proposed training and testing activities in the KWRC and SFOMF would expose ESA-listed marine invertebrates to various frequencies of sonar and transducer-produced sounds. Planktonic conch larvae could also be affected, though an effect has not been documented. Current research indicates that protected coral species and queen conch primarily detect low-frequency sonar or low-frequency components of nearby sonar-related sounds (Morin 2024).

The current scientific evidence suggests that while ESA-listed corals and queen conch can detect and respond to certain acoustic stimuli, their sensitivity is primarily limited to particle motion rather than pressure waves, with sensory capabilities largely restricted to detecting water movement using receptors on their tentacles. This biological limitation naturally reduces the potential impact of sonar operations on coral or queen conch populations. The exterior cilia of coral larvae may help them detect nearby water movements, but their ability to sense acoustic signals is confined to very short distances from the source. Research suggests that only invertebrates very close to intense sound sources might experience impacts to sensory structures like statocysts. Although coral and conch larvae could potentially experience brief particle motion from nearby sonar exposure, available scientific evidence does not indicate this would cause biologically meaningful effects.

In addition, most sonar operations occur seaward of coastal zones, minimizing potential impacts since these areas generally contain less habitat for ESA-listed invertebrates (Morin 2023). While some ESA-listed coral species inhabit deeper mesophotic waters beyond the coastal zone, direct exposure to intense sonar is unlikely as such proximity would create navigation hazards that Navy vessels actively avoid (Pysanczyn et al. 2023).

While ESA-listed invertebrates that detect low-frequency sounds may exhibit behavioral changes during training or testing activities, current scientific understanding does not support that acoustic sources or vessel sounds at predicted levels in the operational areas would cause significant biological impacts. The relatively simple sensory mechanisms of these species, combined with their habitat distribution patterns and existing military operational protocols, indicates that acoustic impacts from military training activities likely have insignificant effects on these ESA-listed species. Therefore, the likely effects from exposure to sonar and other transducers resulting from the proposed action on ESA-listed corals and queen conch are considered minor and insignificant, and thus may affect but are not likely to adversely affect these species within the action area.

6.4.2 Explosives

The deployment of explosive devices during military training and testing activities presents significant challenges for marine ecosystems, particularly for vulnerable species such as corals and queen conch. This section analyzes the potential impacts of in-water explosive stressors from the proposed action that may affect ESA-listed coral species or queen conch within the AFTT action area.

Exposure Analysis

Corals

The use of in-water explosives during AFTT activities may affect, and is likely to adversely affect boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, staghorn coral. While military operations involving explosives can generate pressure waves, sediment and military expended materials released into the ocean, extensive mitigation measures exist to minimize the impacts of these explosive stressor on ESA-listed corals.

The depth distribution pattern of ESA-listed corals directly influences their potential exposure to military activities involving explosives and associated expended materials. ESA-listed corals exhibit varying depth preferences within the action area, with most species concentrated in waters up to 30 m deep. However, certain species demonstrate broader depth ranges, particularly within the star coral complex. Boulder star and mountainous star corals show notable presence in deeper waters, dominating depths between 40 to 50 m and maintaining significant populations up to 90 m, especially in areas between Puerto Rico's eastern coast and the Virgin Islands.

The AFTT action area contains approximately 4,724 km² of shallow-water coral reef habitat. The areas of greatest concern for explosive impacts are concentrated in the KWRC and South Florida Ocean Measurement Facility Testing Range (SFOMF), where training and testing activities overlap with known distributions of ESA-listed coral species. Within the KWRC, important coral habitat areas include Pulley Ridge and the Florida Reef Tract. However, recent surveys of Pulley Ridge have not documented any ESA-listed coral species in this area despite multiple survey efforts. This significantly reduces the potential impact area for ESA-listed corals in this region. The shelf break connection to the Florida Reef Tract represents another area of potential overlap, though again, ESA-listed coral species have not been observed in survey locations intersecting the KWRC or Gulf Range Complex.

The Navy implements specific mitigation measures for seafloor resources during explosive activities. These include geographic restrictions around known coral habitats and operational protocols designed to minimize potential impacts. Notable exemptions from critical habitat designations include areas around NAS Key West and portions of the SFOMF Testing Range, totaling approximately 5.5 square miles. However, these exemptions do not preclude the need for protective measures during training and testing activities. Based on the available geographic data and operational parameters, the actual area where explosive impacts could affect shallow-water coral habitats is extremely limited. The majority of coral reef areas either fall outside training and testing ranges or are protected by sanctuary status (e.g., Flower Garden Banks and Florida Keys National Marine Sanctuaries). Additionally, recent surveys indicate that many areas of potential overlap do not contain ESA-listed coral species. While the total coral reef area within AFTT is substantial, the combination of geographic restrictions, sanctuary protections, and actual species distribution patterns significantly reduces the potential impact zone from in-water explosive activities.

With the exception of mine neutralization and explosive ordnance disposal training that occurs in the operating areas and an associated inshore location of the KWRC, munitions and other materials are primarily expended far from shore where they may only impact shallow-water coral reefs in mesophotic habitats (water depths to 90 m). For non-buoyant materials that would sink quickly once expended (e.g., large caliber projectiles), impacts to ESA-listed corals or coral critical habitat would only occur if the item were expended within the depth range of these resources and over the top of the particular resource. More buoyant materials expended, including buoys, parachutes, and some pieces of surface or subsurface targets, expended outside of the depth range of ESA-listed corals could still impact these resources if currents were to bring these items into areas within the depth range of ESA-listed corals. Figure 64 shows the major current systems in the portion of the action area that overlaps with the range of ESA-listed corals. The major currents most relevant to this discussion are the Loop and Florida currents which could bring materials expended in portions of the KWRC outside the depth distribution of ESA-listed corals to more nearshore areas around the southeastern coast of Florida. However, there is no information to indicate the frequency in which expended items from AFTT explosives

may settle within the action area in locations where ESA-listed corals occur, versus being transported to other locations outside of the distribution and depth range of these resources.

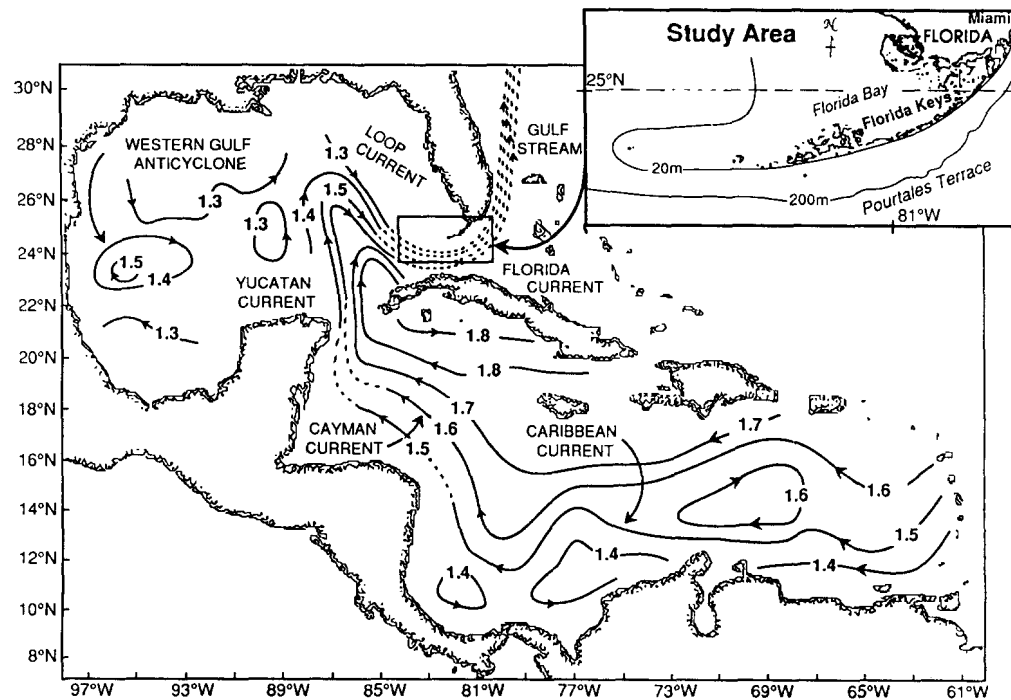


Figure 64. Major Current Systems in the Portion of the Action Area within the Range of ESA-listed Corals (Lee et al. 1992)

At SFOMF, the vast majority of material would be expended outside of the depth range of ESA-listed corals. For items that sink quickly and are expended outside of the depth range of ESA-listed corals, we would not anticipate impacts to ESA-listed corals. For more buoyant items, based on the current patterns in this locations (e.g., the Florida Current flowing to the Gulf Stream), we would anticipate that most of these items would be transported north out of the range of ESA-listed corals and coral critical habitat. According to supplemental information provided by the Navy during consultation, the materials that could be expended within the range of ESA-listed corals at this location are surface and subsurface targets (total of 223 targets annually). Based on the size of each of these items and the number proposed annually, the total footprint of these items if/when they settle to the seafloor is approximately 3,500 m².

Most importantly, the vast majority of seafloor habitat in the KWRC and SFOMF that could be impacted by military expended materials is not inhabited by ESA-listed corals or designated coral critical habitat. Some of the explanation for this is provided above: i.e., a large percentage of materials will be expended outside of the depth distribution of ESA-listed corals or coral critical habitat, and currents are likely to carry many expended items to locations where ESA-listed corals do not occur. In addition, based on the available surveys, even within the depth distribution of ESA-listed corals the majority of seafloor habitat in these areas do not contain these or any other coral species. As previously noted, even within areas that are shallow water

coral reefs or contain hard bottom that may be suitable for coral recruitment, a small percentage of this area would be expected to contain live coral (Reed et al. 2014; Smith et al. 2023), and an even smaller percentage of this area would contain ESA-listed coral species. As described above, we anticipate some instances where materials expended during AFTT in-water explosive activities will likely make physical contact with ESA-listed corals causing harm to these resources. However, available information does not allow us to determine specifically where impacts will occur within the KWRC or SFOMF, what specific military expended material will result in impacts, or to provide a quantitative prediction of how frequently impacts will result. Further, site-specific information on the abundance and density of ESA-listed corals is not available for most locations in the action area. Even though surveys have been conducted in some locations within the action area, coral reef communities are highly variable with species presence/absence, colony density, colony size and morphology, and other factors varying over small spatial scales (e.g., a few meters separate forereef and backreef habitats, which can have radically different coral communities).

While density information may be available for ESA-listed corals in some specific locations, it would not be accurate or appropriate to assume these density estimates are applicable everywhere within the range of these species or everywhere in the action area. For this reason, for the AFTT proposed action, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take of ESA-listed coral colonies, or to monitor take-related impacts in terms of individuals of these species. Therefore, the incidental take of ESA-listed corals is expressed as a habitat area surrogate as prescribed by 50 CFR 402.14(i).

The KWRC and SFOMF represent the primary areas where AFTT in-water explosive activities intersect with coral habitats. At SFOMF, the vast majority of material would be expended outside of the depth range of ESA-listed corals. Figure 65 provides information on substrate type in the KWRC. Within these regions, hard bottom that could provide suitable habitat for coral recruitment represents up to 17.9% of the substrate within the depth range of ESA-listed corals and/or areas within 12 NM of the shoreline (Reed et al. 2014). Other habitat types that would not be suitable for coral recruitment (i.e., intermediate [e.g., non-stable cobble] or soft substrates) comprise the rest of available habitat. However, even within these potentially suitable areas, actual coral presence is significantly lower. Surveys at both Pulley Ridge and the Dry Tortugas found coral cover of just 1.29% and 0.60% respectively, indicating that even in protected areas, coral abundance remains limited (Reed et al. 2014; Smith et al. 2023).

Given the available data from these specific operational areas, and applying a conservative 1.5% coverage estimate, based on Reed et al. (2014), to areas where explosive activities could potentially occur, the maximum theoretical impact areas would be: KWRC: 5.2 km² of potential impact area; SFOMF: 0.8 km² of potential impact area.

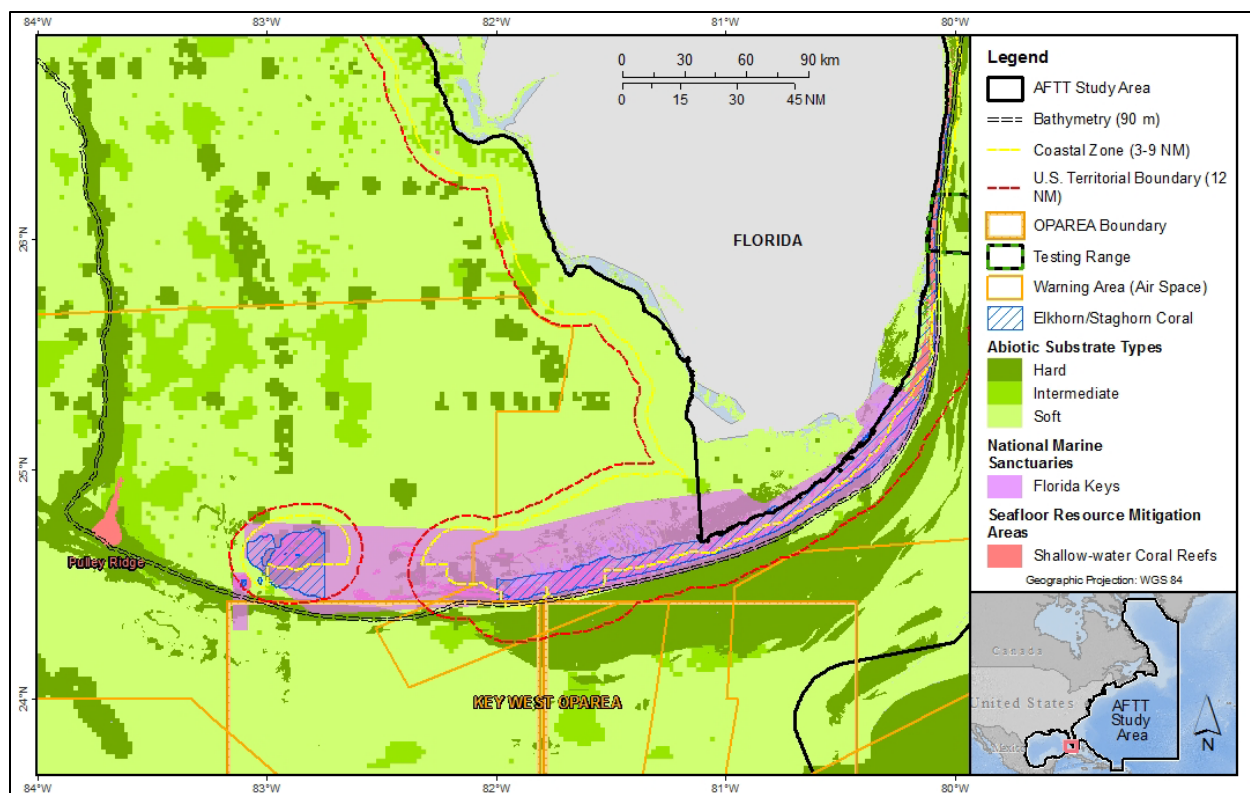


Figure 65. Distribution of Known Shallow-water Coral Reefs and Hard Substrate Suitable for Shallow-water Coral Reef Species (< 90 m deep) in the South Florida Portion of the Action Area.

However, these calculated areas of impact represent conservative, maximum estimates based on documented shallow water zones where military activities could potentially overlap with potential coral habitat, while accounting for operational restrictions and established mitigation measures in both training ranges. Within the KWRC, the Navy approximates that training exercises using in water explosives impact less than one acre, or roughly 4,047 m², each year. Based on habitat mapping information from the AFTT Marine Habitat Database Technical Report, coral cover in Key West and the Gulf of America training zones ranges from 5% to 20% of the total area impacted by explosives (Navy 2024g). Applying these proportions to the estimated area impacted by explosives, we estimate that the total coral habitat area directly affected annually falls between 202 and 809 m². The 2018 AFTT Phase III biological opinion identified an estimate of 0.13 acres or approximately 526 m², which falls into the estimate and coincides with historical impact area calculations for the KWRC and SFOMF.

As mentioned above, approximately 17.9% of the substrate within coral depth ranges consists of hard bottom suitable for coral recruitment (Navy 2024g), but actual coral cover in these areas of suitable habitat is significantly lower (Reed et al. 2014). Within the estimated impact zone, coral coverage analysis indicates relatively sparse distribution of ESA-listed species. Based on habitat surveys showing an average living hard coral coverage of about 1.5% (Reed et al. 2014), we

estimate that the ESA-listed coral-occupied area within the explosives impact zone is approximately 7.89 m^2 ($526.1 \text{ m}^2 \times 0.015$).

As compared to sedentary adult coral colonies, mobile coral larvae could be susceptible to effects of in-water explosives stressors throughout a larger portion of the action area. Entrapment in expended materials could cause immediate mortality of coral larvae or prevent larvae from locating somewhere to settle and grow while the larvae are still viable (typically, coral larvae survive for a few weeks). The initial days following coral spawning represent a particularly vulnerable period for coral larvae. During this pelagic phase, larvae must maintain sufficient energy reserves while avoiding numerous environmental and biological stressors. Research has shown that unfed coral larvae can experience high early mortality due to depleted energy reserves (Harrison et al. 2021). Once the coral spat gain symbionts and develop tentacles, they can begin to feed in the same manner as adults, namely through autotrophy and planktotrophy, respectively. This vulnerability is amplified by the need to locate suitable settlement substrate while simultaneously managing their limited energy resources. The duration of this critical period typically extends through the first several days post-release, during which larval mortality rates are naturally elevated. Although we anticipate that AFTT explosive activities will impact some ESA-listed coral larvae, we do not have sufficient information on the distribution or abundance of coral larvae or the spatial overlap with AFTT explosive stressors to quantify this impact.

Queen Conch Exposure

The use of explosives within the AFTT action area presents a risk to ESA-listed queen conch populations. While direct mortality studies specific to queen conch are limited, research on marine invertebrates has demonstrated that underwater explosions can have significant impacts on marine life (Gitschlag et al. 2001). Queen conch populations demonstrate particular sensitivity to anthropogenic disturbances due to their specific life history characteristics. The pathways of mortality for queen conch in relation to AFTT operations can be traced through several mechanisms. Physical disturbance of their preferred sandy algal flats and seagrass bed habitats can directly impact both adult and juvenile populations. Juveniles are particularly vulnerable as they are primarily associated with seagrass beds, which can be damaged or destroyed by military activities involving explosives. The species' requirement for direct contact during mating makes populations especially sensitive to any activities that reduce population density or alter habitat quality. Queen conch populations, with their extended maturation period of 3.5 to 4 years and specific habitat requirements, may experience prolonged recovery periods following habitat disturbance.

Queen conch are relatively sedentary, with documented movement patterns showing they typically traverse only a few meters per day and maintain limited home ranges of 0.1 to 1.85 hectares (Farmer and Doerr 2022). This limited mobility makes them especially vulnerable to localized environmental impacts. The AFTT BA indicates that the impact area of explosions near the seafloor at Demolition Key is approximately 1.6 acres per year or $6,475 \text{ m}^2$.

Surveys conducted in the KWRC and South Florida habitats by HDR Environmental Operations and Construction Inc. in 2013 estimated a queen conch density of between 15.1 to 17.3 adults per acre, which translates to roughly 3.72 to 4.27 conch per 100 m², in affected areas (Navy 2024g; Navy 2024k). With the estimated seafloor area affected annually of 6,475 m², and a queen conch density of 3.72 to 4.27 conch per 100 m², the estimated number of queen conch exposed to explosive impacts within the impact zone can be calculated as:

Conch Population Exposed = Impact Area * Conch Density

Conch Population Exposed = 6,475 m² * (3.72 to 4.27 conch/100 m²)

Conch Population Exposed = 241 to 277 conch

Response Analysis

Coral Response

Explosive activities in marine environments generate multiple stressors that affect coral species in various ways. The most immediate impact comes from pressure waves that can injure or kill coral in the vicinity of detonations. The pressure waves create intense shock fronts that can cause immediate physical trauma to marine organisms, while subsequent pressure changes can affect their physiological functions. The assessment of the extent of marine invertebrate mortality within a specified explosive impact zone requires careful analysis of multiple mortality pathways and their respective spatial influences. By examining distinct impact mechanisms and applying established mortality thresholds, we can develop refined estimates of potential coral loss within this confined area. Debris or military expended materials such as explosive fragments can also cause physical trauma if the species is concurrent in the blast range of the explosive device. Secondary stressors include sediment disturbance and displacement, which can result in increased turbidity and potential smothering of coral and other benthic invertebrates. These secondary effects can trigger cascading impacts throughout the reef ecosystem, affecting not only corals but also the diverse array of marine life that depends on healthy reef habitats for survival. Potential impacts on invertebrates resulting from the pressure wave effects, physical strike impacts from expended materials, and from secondary impacts from sedimentation and interactions with secondary environmental stressors resulting from a detonation, are discussed in this section. We then quantify the ESA-listed coral area impacted by each stressor type and estimate the anticipated mortality rate within each affected area.

Pressure Wave Effects

Explosive detonations in marine environments generate immediate and intense pressure changes that propagate through the water column. 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. Underwater explosions demonstrate varying effects based on depth, with research indicating significant changes in shock wave characteristics across different water depths. Studies have shown that explosive impacts can occur at depths ranging from 100 to 600

m (Gao et al. 2024), with shock wave energy decreasing as water depth increases (Gao et al. 2024). This depth-dependent relationship plays a crucial role in determining the environmental impact of explosive activities on marine ecosystems. Explosives in open water, which are not contained completely by rigid structures, will produce both higher amplitude and higher frequency shock waves than contained detonation.

Pressure wave impacts can be particularly severe in shallow water environments where coral are found. The physical trauma from explosive shock waves can cause immediate mortality, while secondary effects may include damage to habitat structures and disruption of feeding patterns. Pressure wave impacts extend beyond direct physical contact zones. Based on experimental studies of explosive effects on marine invertebrates, pressure waves create mortality zones with distinct patterns. Within 90 m of the detonation point, for a 5 lb. NEW, pressure waves can cause immediate tissue mortality.

The immediate effects of explosive detonations on coral communities create devastating localized damage patterns that vary by species morphology and colony structure. When explosives detonate near reef systems, they generate intense pressure waves that can crack and stress corals, these forces can rupture delicate tissue structures and disrupt the essential symbiotic relationships between coral polyps and their zooxanthellae, the symbiotic algae essential for their survival, leading to extensive damage across large sections of reef structure (Huang and Roy 2013). At the cellular level, explosive shock waves trigger complex chains of biological responses that can fundamentally alter coral physiology. Studies have shown that corals exposed to severe stress events experience significant changes in their protein profiles and cellular metabolic processes (Tisthammer et al. 2021). These molecular alterations can affect essential functions such as tissue repair, reproduction, and energy metabolism. The disruption of these fundamental biological processes creates lasting impacts that extend well beyond the immediate blast zone and initial damage period. The physical trauma extends beyond surface damage, often causing extensive internal injuries that may not be immediately visible but prove fatal to affected colonies over time. In coral communities, these effects can trigger mass mortality events, with studies indicating mortality rates that can reach up to 70% to 90% within the immediate blast zone (Fox and Caldwell 2006). Marine inverts outside the immediate impact zone of underwater explosions may still detect the acoustic signals generated by these events. As explosive impulses travel through water, they undergo a transformation - the sharp pressure peaks characteristic of near-field explosions gradually attenuate and evolve into more continuous acoustic waves. However, for marine invertebrates, detection of these modified sound waves remains constrained by their biological limitations. As discussed in Section 6.4.1, these creatures primarily sense water movement rather than pressure waves, and their sensitivity is largely restricted to nearby low-frequency disturbances.

Physical Strike from Expended Materials

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. Direct physical impacts from military training and testing activities pose significant risks to reef structure and function. Explosive detonations near reef systems can cause immediate and lasting damage to coral communities. The physical impact typically creates rubble craters approximately 1 to 2 m in diameter, with mortality rates ranging from 50-80% of coral coverage within the immediate blast zone (Lewis 1997; Shannon 2017). Physical impacts from military training and testing activities create immediate mortality through several mechanisms. Based on documented responses to physical disturbance, approximately 35.5% of affected colonies experience mortality within 18 months of initial impact (Smith et al. 2023). This initial damage phase demonstrates how explosive forces can fundamentally alter reef structure and compromise the basic biological functions of affected colonies. The combination of physical trauma and initiated stress responses often exceeds the natural resilience of coral communities, leading to extensive mortality in blast-affected areas. Studies have documented that recovery from even a single small blast directly on a reef can take between 5 to 10 years (Huang and Roy 2013). This extended recovery period highlights the persistent nature of physical damage to reef ecosystems.

The pattern of damage from explosive activities demonstrates distinct spatial characteristics, with impact intensity varying significantly based on proximity to blast sites. Within the immediate blast zone, explosive forces create devastating levels of coral mortality through direct physical destruction. The damage extends beyond the primary impact area, as the resulting coral rubble can shift in ocean currents, creating what researchers describe as "killing fields" that prevent successful coral recruitment and recovery (Leung and Mumby 2024). These unstable substrates pose particular challenges for reef rehabilitation, as they continue to cause damage long after the initial explosive event. The long-term effects of military training and testing on coral reef ecosystems represent a complex interaction of direct physical impacts, acoustic disturbance, and chemical contamination. While some impacts, such as explosive damage, can persist for decades, others may be effectively managed through careful implementation of mitigation measures.

Explosions may impact invertebrates at the water surface, in the water column, or on the bottom substrate. 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 the response of ESA-listed invertebrates to explosive AFTT activities varying depending on proximity and deployment location. Whereas AFTT explosive activities occur in both offshore and inshore waters, most detonations would occur in water depths greater than 200 ft (but still at the surface), and outside of state coastal waters which is seaward of most shallow-water coral reefs and other shallow-water habitats. The exceptions would be at the deeper end of shallow-water coral reefs that are seaward of the coastal zone and represented by Pulley Ridge in the KWRC. Based on supplemental information provided by the Navy during consultation, no

explosive ordnance would be used within the depth range of ESA-listed corals at SFOMF. For this reason, we do not anticipate explosives will impact ESA-listed corals at this location.

Surface explosions generally occur seaward of the coastal zone, typically more than 12 NM from shore, where coral larvae would be carried away from critical habitat by natural currents. This positioning significantly reduces potential impacts on coral recruitment and settlement patterns.

Military training and testing exercises involving explosive elements, whether single detonations or multiple sequential charges, are typically conducted within defined time windows. This temporal restriction naturally limits the duration of potential acoustic interference. Even in cases where the explosive sounds might temporarily mask biologically significant acoustic cues, such as those used for navigation or communication, the masking effect would be momentary rather than persistent. This brief disruption minimizes the likelihood of significant impacts on marine invertebrate behavior or survival. Navy (2017) cited investigations in the Pacific Ocean (Mariana Archipelago) as an example of possible impacts from military expended materials on seafloor habitats. Water areas were not targeted at the Mariana range and bottom impacts occurred only when the target land mass was missed, or the munition bounced off the land into the water. The surveys found no overall long-term adverse impacts to corals or other invertebrates due to expended items, despite several decades of use and observations of intact bombs and fragments on the bottom (Smith and Marx Jr. 2016). Inert 500-lb. bombs were found to disturb a bottom area of 17 m² each, although specific damage to invertebrates was not described. Invertebrates within this footprint would likely have been killed, injured, or displaced depending on the organism. Expended inert items, once settled in place, appeared to become encrusted with marine growth and pose no substantial long-term threat to invertebrates. The condition of corals indicated a healthy environment, with no apparent change in species composition, distribution, size, or stress indicators.

These results are in contrast to findings by Porter et al. (2011) indicating coral health and even the structure of the coral community on reefs in Vieques, Puerto Rico, containing expended and live ordnance, was poor. Corals were also found to have high concentrations of explosive-type compounds in their tissues up to 1 m from ordnance items (Porter et al. 2011; Barton and Porter 2004 cited in Lotufo et al. 2017). A summary of data from military and former military sites around the United States, including in the U.S. Caribbean and Pacific, found that sediments were commonly contaminated in the immediate area of ordnance items and explosive-type compounds and heavy metals were sometimes found in the water column around an item, but mobile species such as fish appeared to be unaffected by contamination (Lotufo et al. 2017). Immediate colony death from direct physical strikes typically affects 50% to 100% of colonies within the impact footprint.

Secondary Impact Response

Secondary impacts to coral 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 reef species 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).

Coral stress response, similar to coral bleaching, represents a severe physiological disruption that can prove fatal to affected colonies. The physical destruction of reef structures can alter water flow patterns, increase sedimentation, and create conditions that favor algal overgrowth. The biological impacts of explosive damage become further complicated by interactions with secondary environmental stressors. Research has demonstrated that surviving corals often face compromised immune systems following explosive events (van de Water et al. 2015). This reduced immunological function leaves them particularly vulnerable to diseases and other environmental challenges. Environmental stressors such as sustained pollution, sedimentation, and ocean acidification can interact synergistically with blast damage to create particularly challenging conditions for coral survival (Oliver et al. 2015). Colonies impacted by debris that are sexually mature may not spawn in the year damage from expended items occurs, or even in subsequent years depending on the extent of the damage.

Area Impacted by Each Stressor Type and Estimated Mortality Rate

The primary impact zone is the area immediately surrounding an underwater explosion where the pressure wave, fragmentation, and cratering effects result in immediate mortality or severe structural damage to coral colonies and other benthic organisms. The range to 90% survivability for large caliber explosives (about 5 lbs) that would be used is estimated at approximately 30 m. Corals within this radius experience high mortality rates due to tissue shearing, fragmentation, and polyp detachment. The combination of immediate blast trauma, delayed internal injuries, and secondary effects supports the claim that coral mortality rates in the immediate impact zone can reach 70% to 90%. These findings align with military training impact assessments and historical studies on explosive impacts to coral reefs (Navy 2024c; Navy 2024b).

For the identified shallow water explosive areas within AFTT at least 40% of coral colonies falls within primary impact zones, experiencing immediate mortality through multiple pathways (pressure wave & direct strike).

- $7.89 \text{ m}^2 * 0.40 = 3.16 \text{ m}^2$

Typical explosive charges used in AFTT training (5 to 20 lbs.) in areas where ESA-listed coral may occur create craters ranging from approximately 12.5 m² per detonation (Navy 2024c).

The secondary impact zone extends beyond the immediate blast radius but experiences long-term degradation from, resuspended sediment and siltation, changes in water flow dynamics, and increased turbidity affecting coral photosynthesis. Corals rely on symbiotic zooxanthellae algae for energy. Sediment plumes block light penetration, reducing coral energy production. Explosions cause a temporary sediment plume, which can remain suspended for several hours to days, depending on local currents. Some coral species cannot actively shed sediments and suffer mortality rates of approximately 35.5% when exposed to chronic burial (Smith et al. 2023). Loss of reef structure from repeated blasts reduces habitat complexity, making corals more vulnerable to future disturbances.

- 3.95 m² (50% of coral-occupied space) lies within secondary impact zones, experiencing delayed or partial mortality through sedimentation and secondary effects (rubble scouring, and military expended material deposition.)

Applying the 35.5% mortality rate identified in Smith et al. (2023), this results in approximately 1.40 m² of additional coral loss over time.

Table 73. Summary of Estimated ESA-listed Coral Mortality Resulting from AFTT Explosive Activities

<i>Estimated Coral Area Affected (m²)</i>		<i>Mortality Rate</i>	<i>Total Coral Loss (m²)</i>
Primary Impact Zone	3.16 m ²	~100%	3.16 m ²
Secondary Impact Zone	3.95 m ²	~35.5%	1.40 m ²
Total Area Annual Coral Mortality			4.56 m ²
7 Year Area of Coral Mortality			7.89 m ²

Total yearly ESA-listed coral mortality from AFTT explosive operations in a given year is estimated at 4.56 m². This assumes that the percent coral cover used for our analysis is reasonably accurate for the portion of the action area where ESA-listed coral would be exposed to explosives. This estimate could change over time with updated surveys to verify coral cover. While 4.56 m² represents our estimate of the annual area of ESA-listed coral mortality, we do not anticipate this level of mortality every year since AFTT explosive activities affecting coral are typically conducted in the same (or very similar) locations year after year. The total 7-year estimated mortality to ESA-listed corals in the shallow water explosive zone identified in proposed action would not exceed 7.89 m², which, based on our exposure analysis above, represents the estimated total area occupied by ESA-listed corals within the AFTT explosives impact zone.

Queen Conch Response

Direct mortality rates for queen conch exposed to explosives are not available. Instead, we look to information from studies on other invertebrates (e.g., shrimp, lobster, oysters and crabs) to

inform our analysis. Data from several experiments (Aplin 1947; Chesapeake Biological Laboratory 1948; Gaspin et al. 1976) were used to develop curves (Figure 66) that estimate the distance from an explosion beyond which at least 90% of shrimp, lobster, oyster, and crabs would survive, depending on the weight of the explosive (Young 1991). Given the physiological similarities between queen conch and oysters, we can use this information as a surrogate to help inform our estimate of a lethal range.

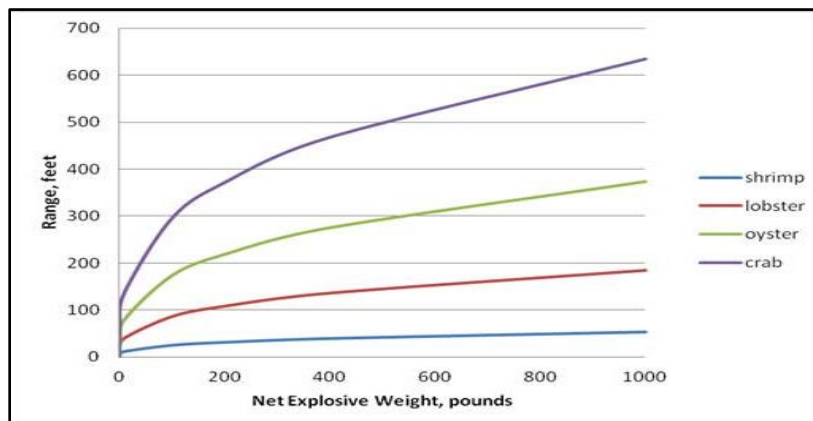


Figure 66. Prediction of Distance to 90% Survivability of Marine Invertebrates Exposed to an Underwater Explosion (Young 1991)

Survivability curves suggest that 90% of invertebrates survive beyond 30 m from a 5-lb NEW explosive charge. With a 10% mortality rate due to proximity to explosions, the annual queen conch mortality is estimated to be between 24 and 28 individuals. Thus, we estimate the mortality of 24 to 28 individual queen conch per year due to AFTT explosive training activities at Demolition Key.

Sub-lethal injuries to queen conch could increase mortality beyond what we observe in direct blast zones. Queen conch reproduction is particularly sensitive to population density changes, as these organisms require direct contact for mating. Current population assessments indicate concerning trends, with many jurisdictions reporting adult densities below the critical threshold of 50 adult conch per hectare required for any reproductive activity. Military activities that reduce population density or alter habitat quality can significantly impact reproductive success. Recent research indicates that many queen conch populations are currently experiencing recruitment failure due to low encounter rates and mate-finding difficulties this situation is exacerbated by any additional environmental stressors.

6.5 Summary of Effects Determinations

Table 74. NMFS ESA effects determinations by stressor for each ESA-listed species and critical habitat, and overall effects determination for each species and critical habitat (LAA = likely to adversely affect; NLA = not likely to adversely affect; NE = no effect)

ESA-Listed Species	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors				Entanglement Stressors			Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	Electromagnetic Devices	High Energy Lasers	Vessels	In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/ Parachutes	Biodegradable Polymer	Military Expended Materials- Munitions	Military Expended Materials – Other	
Marine Mammals																				
Blue whale	LAA	LAA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Fin whale	LAA	LAA	LAA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Rice’s whale	LAA	LAA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
North Atlantic right whale	LAA	LAA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Sei whale	LAA	LAA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Sperm whale	LAA	LAA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Sea Turtles																				
Green – North Atlantic DPS	LAA	LAA	LAA	NLA	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Hawksbill	LAA	LAA	NLA	NLA	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Kemp’s ridley	LAA	LAA	LAA	NLA	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Leatherback	LAA	LAA	NLA	NLA	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA

**Biological and Conference Opinion on Navy and Coast Guard
Atlantic Fleet Training and Testing Activities Phase IV**

OPR-2024-02209

ESA-Listed Species	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors				Entanglement Stressors			Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	Electromagnetic Devices	High Energy Lasers	Vessels	In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/ Parachutes	Biodegradable Polymer	Military Expended Materials- Munitions	Military Expended Materials – Other	
Loggerhead – Northwest Atlantic DPS	LAA	LAA	LAA	NLA	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Fishes																				
Atlantic salmon - Gulf of Maine DPS	LAA	NLA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Atlantic Sturgeon – Gulf of Maine DPS	LAA	NLA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Atlantic Sturgeon – New York Bight DPS	LAA	NLA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Atlantic Sturgeon – Chesapeake Bay DPS	LAA	NLA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Atlantic Sturgeon – Carolina DPS	LAA	NLA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA

**Biological and Conference Opinion on Navy and Coast Guard
Atlantic Fleet Training and Testing Activities Phase IV**

OPR-2024-02209

ESA-Listed Species	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors				Entanglement Stressors			Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	Electromagnetic Devices	High Energy Lasers	Vessels	In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/ Parachutes	Biodegradable Polymer	Military Expended Materials- Munitions	Military Expended Materials – Other	
Atlantic Sturgeon - South Atlantic DPS	LAA	NLA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Gulf sturgeon	LAA	NLA	NLA	NLA	NLA	NLA	NLA	LAA	NLA	NE	LAA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Shortnose sturgeon	NLA	NLA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Giant Manta Ray	LAA	NLA	NLA	NLA	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Nassau Grouper	NLA	NLA	NE	NE	NLA	NLA	NLA	NLA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Oceanic whitetip shark	LAA	NLA	NLA	NE	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Scalloped hammerhead sharks – Central and Southwest Atlantic DPS	LAA	NLA	NE	NE	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Smalltooth sawfish – U.S. portion of range DPS	LAA	NLA	NLA	NLA	NLA	NLA	NLA	LAA	NLA	NE	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA	NLA
Invertebrates																				

**Biological and Conference Opinion on Navy and Coast Guard
Atlantic Fleet Training and Testing Activities Phase IV**

OPR-2024-02209

ESA-Listed Species	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors				Entanglement Stressors			Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	Electromagnetic Devices	High Energy Lasers	Vessels	In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/ Parachutes	Biodegradable Polymer	Military Expended Materials- Munitions	Military Expended Materials – Other	
Elkhorn coral	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NE	NE	NE	NE	NE	NLA
Staghorn coral	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NE	NE	NE	NE	NE	NLA
Pillar coral	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NE	NE	NE	NE	NE	NLA
Rough cactus coral	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NE	NE	NE	NE	NE	NLA
Lobed star coral	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NE	NE	NE	NE	NE	NLA
Mountainous star coral	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NE	NE	NE	NE	NE	NLA
Boulder star coral	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NE	NE	NE	NE	NE	NLA
Queen conch	LAA	NLA	NE	NE	NLA	NE	NE	LAA	NE	NE	NE	NLA	NLA	NLA	NLA	NLA	NLA	NE	NE	NLA
Critical Habitat																				
North Atlantic right whale	NLA	NE	NLA	NE	NE	NE	NE	NLA	NE	NE	NLA	NLA	NE	NE	NE	NE	NE	NE	NE	NE
Rice's whale	NLA	NLA	NLA	NE	NLA	NLA	NLA	NLA	NE	NE	NLA	NLA	NE	NE	NE	NE	NE	NE	NE	NE
Loggerhead – Northwest Atlantic DPS	NLA	NLA	NLA	NE	NLA	NLA	NLA	NLA	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Green sea turtle - North Atlantic DPS	NLA	NLA	NLA	NE	NLA	NLA	NLA	NLA	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

**Biological and Conference Opinion on Navy and Coast Guard
Atlantic Fleet Training and Testing Activities Phase IV**

OPR-2024-02209

ESA-Listed Species	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors				Entanglement Stressors			Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	Electromagnetic Devices	High Energy Lasers	Vessels	In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/ Parachutes	Biodegradable Polymer	Military Expended Materials- Munitions	Military Expended Materials – Other	
Critical Habitat (continued)																				
Atlantic sturgeon – All DPSs	NLA	NLA	NE	NE	NLA	NE	NE	NLA	NE	NE	NLA	NLA	NLA	NLA	NE	NE	NE	NE	NE	NE
Nassau grouper	NLA	NE	NE	NE	NE	NE	NE	NLA	NE	NE	NE	NE	NLA	NLA	NE	NE	NE	NE	NE	NE
Gulf sturgeon	NLA	NLA	NE	NE	NLA	NE	NE	NLA	NE	NE	NLA	NLA	NLA	NLA	NE	NE	NE	NE	NE	NE
Elkhorn and Staghorn	NLA	NE	NE	NE	NE	NE	NE	NLA	NE	NE	NE	NE	NLA	NLA	NE	NE	NE	NE	NE	NLA
Boulder star, lobed star, mountainous star, pillar, and rough cactus coral	NLA	NE	NE	NE	NE	NE	NE	NLA	NE	NE	NE	NE	NLA	NLA	NE	NE	NE	NE	NE	NLA

7 CUMULATIVE EFFECTS

“Cumulative effects” are defined in the regulations as “those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation” (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7(a)(2) of the ESA.

We assessed the action area of this consultation for any non-Federal activities that are reasonably certain to occur. The past and ongoing impact of existing actions was described in the Environmental Baseline (Section 5). During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline, most of which we expect will continue in the future. An increase in these activities could similarly increase their effects on ESA-protected resources and for some, an increase in the future is considered reasonably certain to occur. Given current trends in global population growth, threats associated with changing environmental conditions, ocean pollution, fisheries bycatch, vessel strike, offshore wind development, and anthropogenic sound are likely to continue to increase in the future, although an increase in conservation and management activities may somewhat counter any increase in effects. In contrast, more historic threats such as whaling and sea turtle harvest are likely to remain low or potentially decrease. For the remaining activities and associated threats identified in the Environmental Baseline, and other unforeseen threats, the magnitude of increase and the significance of any anticipated effects remain unknown. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on ESA-protected resources. Thus, this consultation assumes future effects will be similar to those in the past and, therefore, are reflected in the anticipated trends described in the Status of the Species and Critical Habitat Likely to be Adversely Affected (Section 4.2.1) and Environmental Baseline sections of this opinion.

8 INTEGRATION AND SYNTHESIS

This opinion includes a jeopardy analysis for the ESA-listed threatened and endangered species that are likely to be adversely affected by the action. Section 7(a)(2) of the Act and its implementing regulations require every Federal agency, in consultation with and with the assistance of the Secretary (16 U.S.C. §1532(15)), to insure that any action it authorizes, funds, or carries out, in whole or in part, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The jeopardy analysis, therefore, relies upon the regulatory definitions of *jeopardize the continued existence of*. *Jeopardize the continued existence of* means “to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by

reducing the reproduction, numbers, or distribution of that species” (50 CFR §402.02).

Recovery, used in that definition, means “improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act” (50 CFR §402.02).

The Integration and Synthesis is the final step in our jeopardy analyses. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7), taking into account the status of the species, critical habitat, and recovery planning (Section 4), to formulate the agency’s biological opinion as to whether the Action Proponents can insure their proposed actions are not likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

8.1 Jeopardy Analysis

The jeopardy analysis assesses the proposed actions’ effects to ESA-listed species’ survival and recovery. The following sections summarize the relevant information in this opinion for each individual species considered.

8.1.1 North Atlantic Right Whale

The North Atlantic right whale population estimate at the start of 2023 was 372, of which 70 are known reproductive females with previous evidence of calving (Linden 2024a). The western North Atlantic population demonstrated overall growth of 2.8% per year between 1990 to 2010 from an estimated 270 individuals to 481 individuals (Pace et al. 2017; Hayes et al. 2023). However, this period of growth was followed by a period of decline from 2010 to 2020 when overall abundance declined 23.5%, from an estimated 481 to 338 individuals (Hayes et al. 2023). While the population continues to be in decline since 2011, the sharp decrease observed from 2015 to 2020 appears to have slowed, and the short-term trend (2021 to 2023) is positive (Linden 2024a).

The collapse in fecundity of breeding females and the failure of pre-breeders to start breeding are important factors in the current North Atlantic right whale decline in abundance (Reed et al. 2022). The available evidence suggests that at least some of the observed variability in the calving rates is related to variability in nutrition as evidenced by poor body condition (Fortune et al. 2013)(Stewart et al. 2021)(Miller et al. 2011; Christiansen et al. 2020). Slow growth and poor body condition have been linked to a combination of documented regime shifts in primary feeding habitats (Record et al. 2019; Meyer-Gutbrod et al. 2023), and increased energy expenditures related to non-lethal entanglements (Rolland et al. 2016; van der Hoop et al. 2017b), which will likely continue to negatively impact calving rates. In 2017, NMFS declared an UME for this species that is still ongoing due primarily to right whale entanglement in fishing gear and vessel strike. Given the current status and low population size, the species’ resilience to future perturbations is considered very low.

North Atlantic right whales are expected to experience AINJ, TTS, significant behavioral responses, and physiological stress responses throughout waters off the Atlantic Coast from AFTT sonar and explosives. Based on the quantitative acoustic effects analysis (i.e., NAEMO), 109 instances of behavioral harassment, 305 instances of TTS, and up to two instances of AINJ are reasonably certain to occur annually, in a maximum year of AFTT sonar and explosive activities. Most impacts would occur in the Northeast in the spring and winter, when North Atlantic right whales have a higher density at feeding grounds located near and south of Cape Cod (Navy 2024c). In comparison to impacts in other parts of their range, there would be fewer impacts to North Atlantic right whales in identified calving habitat, although a small number of exposures to mother-calf pairs resulting in significant behavioral responses and TTS are anticipated. Based on the best available information, no non-auditory injury or mortality of this species is anticipated from AFTT activities involving sonar and other transducers, air-guns or explosives. Additionally, no vessel strike of North Atlantic right whales is anticipated (see Section 6.1.2 for details).

As described in greater detail in Section 6.1.1, we do not anticipate the predicted instances of TTS or behavioral harassment to result in long-term fitness consequences affecting the reproduction or survival of North Atlantic right whales. Any adverse effects resulting from TTS or behavioral responses are expected to be relatively minor and short-term. While energetic costs to exposed individuals may be greater during large-scale military events that occur over multiple days (to weeks) and involve multiple sonar platforms, the proposed North Atlantic right whale mitigation measures (Section 2.3.2) will likely minimize impacts to this species from such large-scale events. We expect most North Atlantic right whale exposures to sonar and explosives to be episodic and of short duration. The highly migratory movement pattern of right whales reduces the potential for year-round, prolonged exposure from a particular disturbance-inducing activity in a given area. From our acoustic and explosives effects exposure analysis, the average annual number of exposures resulting in TTS or a significant behavioral response per individual North Atlantic right whale is 1.1 (assuming a maximum year of activity levels). While some individual whales may be exposed more often than the average (and some less), based on the available information, it is unlikely that any North Atlantic right whale would have TTS or a significant behavioral response more than five times in a given year. This conclusion is based on the migratory movement pattern of the species, the highly dispersed and sporadic nature of AFTT acoustic stressors throughout the vast action area, and the proposed mitigation measures designed to minimize right whale impacts in areas where they may spend longer periods of time (i.e., foraging or calving grounds). The anticipated small number of instances per year, and short duration per instance, that an individual North Atlantic right whale may suffer from TTS or have a significant behavioral response as a result of the proposed action, provides further support for our conclusion that these impacts are not likely to result in long-term fitness consequences. Similarly, the long-term or chronic physiological stress responses that could potentially result in fitness consequences are not anticipated to occur given the types of AFTT sonar systems proposed and the dispersed nature of sonar use in space and time.

North Atlantic right whales exposed to military sonar can experience masking if the sonar interferes with the animal's ability to communicate with conspecifics or detect biologically relevant sounds. However, masking would be limited for North Atlantic right whales since it could only occur if there is overlap between the sonar sound source frequencies and the low frequency North Atlantic right whale vocalizations. In addition, since masking only occurs in the presence of the masking noise, most instances would be minor and short-term, with no appreciable impacts to the fitness of individual North Atlantic right whales.

The NAEMO analysis estimates that up to seven significant behavioral responses and 19 TTS exposures would occur annually within the Southeast U.S. calving designated critical habitat unit during a maximum year of AFTT activity. An additional seven significant behavioral responses and 25 TTS exposures are predicted during a maximum year within the portion of the Southeast Atlantic calving draft BIA that lies outside of this critical habitat unit.

The NAEMO analysis estimates seven significant behavioral responses and 25 TTS exposures annually with the Southeast Atlantic calving draft BIA in a maximum year of activity. A subset of these exposures within the draft BIA are predicted to occur within the Southeast calving critical habitat unit (i.e., four significant behavioral responses and two TTS). Some proportion of these impacts within calving habitat will likely affect right whale mother-calf pairs. A significant behavioral response to sonar within calving habitat could disrupt activities associated with calf rearing (e.g., nursing young, resting), while TTS and masking could adversely affect mother-calf communication. Based on photo identification data from the North Atlantic Right Whale Consortium Database, in our AFTT Phase III opinion (NMFS 2018a) we estimated that approximately 15% of right whales sighted in these calving areas would be calving females. Based on this information, we estimate that, of the predicted impacts within right whale calving draft BIA, approximately one significant behavioral responses and four TTS would affect mother-calf pairs annually during a maximum year of AFTT activity.

As discussed in Section 6.1.1, mysticete behavioral responses to sonar are typically short term, with the animals returning to their normal behaviors immediately after the sound source is removed. While nursing or resting activities may be temporarily disrupted, we expect mother-calf right whales would return to these activities within seconds to minutes after the response. Given the small number of impacts predicted to mother-calf pairs, the short anticipated duration of those impacts, and the mitigation measures in place to specifically minimize right whale impacts on the calving grounds, it is unlikely that significant behavioral responses to AFTT sonar or explosives would result in any long-term fitness consequences affecting a calf's growth or survival.

A strong behavioral avoidance response by a calf (e.g., swimming away from the sound source) and reduced communication ability, either due to masking or TTS, could increase the risk of mother-calf separation. Depending on the distance and duration, mother-calf separation can increase the risk of other threats such as vessel strike or predation. When on the calving grounds, we would expect mother right whales to remain in close contact with their calves at all times. This would be particularly important after initial exposure to a sound source that produces TTS or a behavioral response. Given their long life spans and habit of returning to the same calving

grounds, it is likely that many mature female right whales have previous experience with military sonar, and have either learned how to respond to it to avoid calf separation, or have become habituated to the sound. Seasonal mitigation measures within the JAX OPAREA and Southeast North Atlantic Right Whale Mitigation Areas would further minimize the likelihood of exposure to sonar and explosives that could result in mother-calf separation. When on the calving grounds, right whale mother-calf pairs are closely monitored through visual aerial surveys. Mitigation requires that sightings data be used when planning event details (e.g., timing, location, duration) to minimize interactions with right whales to the maximum extent practical. In addition, activities involving sonar will be very limited in the Southeast Mitigation Area, and in-water explosives will be prohibited in this calving area where right whales are most vulnerable to anthropogenic threats. With these mitigation measures in place, and considering the other factors discussed above, it is unlikely that the small estimated number of acoustic impacts to mother-calf right whale pairs would result in a mother-calf separation that could lead to fitness consequences.

Mother-calf pairs could also be impacted by sonar and explosives after leaving the calving grounds, either during migrations north to the feeding grounds or when feeding in the Northeast portion of the action area. Although still vulnerable during this life stage, calves would be larger and more mobile than when on the calving grounds, which should reduce their susceptibility to significant adverse effects with fitness consequences from exposure to AFTT sonar and explosives. Our conclusion above that TTS and behavioral response impacts would not result in long-term fitness consequences holds for calves outside of the calving ground, given the small number of anticipated impacts per individual whale and short duration of those impacts.

Unlike TTS, AINJ could be permanent (e.g., PTS), meaning the effects last well beyond the duration of the action and outside of the action area as animals migrate. Permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. As described in more detail in Section 6.1.1, we anticipate that North Atlantic right whale AINJ exposures resulting from the Navy sonar would be of relatively mild severity. The proposed mitigation measures, including the prohibition on using in-water explosives within identified North Atlantic right whale feeding and calving (seasonal restriction) mitigation areas, and small number of AINJ anticipated (i.e., eight total instances every seven years; none from explosives) further reduce the likelihood of a moderate to severe instance of AINJ. Individual right whales exposed to a minor degree of AINJ (i.e., mild severity PTS), could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. No instances of North Atlantic right whale AINJ are predicted to occur within the calving critical habitat unit, largely due to the mitigation measures and limited activities involving sonar or explosives within these areas.

Our conclusion that right whales with mild severity PTS will still be able to perform these important life functions assumes that these individuals are reasonably healthy at the time of exposure, and are not compromised or impacted by other stressors. However, this is not likely to

be the case for all North Atlantic right whales that are exposed to AFTT acoustic and explosive stressors. As discussed above and in Section 4.2.1, other stressors such as chronic entanglement, nutritional stress, and non-lethal vessel strike have been linked to slow growth, poor body condition, and low fecundity rates in North Atlantic right whales. The combination of multiple stressors, either simultaneously or sequentially, could result in cumulative impacts or even synergistic effects on the fitness and survival on individual right whales that are difficult to predict or measure. Whereas the effects of individual stressors on marine mammal health and fitness are often hard enough to quantify, the available information does not allow us to reliably predict or understand the combined effects of multiple stressors (Pirodda et al. 2022b). For some stressor combinations, the cumulative or additive effects on large whale health and fitness are more apparent than for others. For example, non-lethal entanglement can worsen the effects of nutritional stress caused by prey limitations by interfering with prey capture and increasing drag forces while swimming (Pettis et al. 2017b; van der Hoop et al. 2017b). However, for other stressor combinations (e.g., PTS and entanglement, or PTS and prey limitations) the cumulative effects are less clear, and we currently lack the mechanistic understanding and analytical tools to predict their joint outcomes (Pirodda et al. 2022b).

From our effects analysis, we expect that a small number of North Atlantic right whales will experience mild severity PTS, which could make them less efficient at locating conspecifics or have a decreased ability to detect threats at long distances. Whereas chronic entanglement and prey limitations have been linked to increased energy expenditure, poor body condition, and decreased calving rates in North Atlantic right whales, we have no information to indicate that these stressors affect their ability to locate or communicate with conspecifics or to detect threats at long distances. Similarly, we have no information to indicate that auditory injury, in the form of mild severity PTS, will adversely affect a right whale's foraging efficiency or body condition. As discussed above, while PTS could reduce a right whale's efficiency in locating mates, these animals are still expected to be able to find mates and reproduce. We expect that any increased energy expenditure associated with locating conspecifics will be relatively minor given the anticipated mild severity of the PTS exposures, and the small number of right whales that will be affected. Regarding the ability to detect threats, depending on the severity and hearing frequency range affected, PTS could potentially increase a whale's risk of vessel strike if the vessel cannot be detected within a range where avoidance is possible. However, we do not expect that the mild severity PTS predicted will appreciably affect a right whales' ability to detect vessels that are in close range. Given the small number of right whales impacted and the mild severity exposures anticipated, we find it extremely unlikely that PTS resulting from the proposed action will significantly increase the risk of vessel strike. In addition, based largely on the mitigation measures described in Section 2.3.2, we do not anticipate the proposed action will result in a North Atlantic right whale vessel strike. In summary, since we do not anticipate long-term fitness impacts as a result of AINJ exposures, we do not anticipate that instances of AINJ will result in changes in the number, distribution, or reproductive potential of North Atlantic right whales.

One of the objectives of the 2005 North Atlantic Right Whale Recovery Plan (NMFS 2005d) is to significantly reduce sources of human-caused death, injury and disturbance. Criteria for down-

listing the species from endangered to threatened status include a population increase of at least 2% for a period of 35 years, and none of the known threats are limiting the population's growth rate. While AFTT acoustic stressors will likely result in auditory impacts and behavioral disturbance of right whales, long-term fitness impacts are not anticipated. Since these effects are not expected to have long-term fitness consequences, they will not result in an appreciable reduction in the numbers or reproductive rate of North Atlantic right whales. Thus, we do not expect this level of auditory injury, TTS and behavioral disturbance to impact the survival or recovery of this species.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponents will conduct in the AFTT action area on an annual basis, cumulatively over the 7-year MMPA rule, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of the Species or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of North Atlantic right whales in the wild by reducing the reproduction, numbers, or distribution of this species. Similarly, the effects from ongoing AFTT activities and related incidental take specified in the MMPA rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of North Atlantic right whales in the wild. Thus, we determine that the action would not appreciably reduce the likelihood of both survival and recovery of North Atlantic right whales in the wild.

8.1.2 Blue Whale

The current blue whale global mature population size is uncertain, but estimated to be in the range of 5,000 to 15,000 mature individuals (NMFS 2020b). There is no reliable abundance estimate for blue whales in the North Atlantic due to uncertainties in the available data. The estimate of 402 blue whales from the Gulf of St. Lawrence is considered the most robust abundance estimate for the Western North Atlantic stock. While there are insufficient data to determine the blue whale population trend in the Western North Atlantic (Hayes et al. 2020), current estimates indicate a growth rate of around 3% to 4% per year for the eastern North Pacific stock (Calambokidis et al. 2009; Carretta 2021).

Blue whales are only present in the offshore portion of the AFTT action area and may be exposed to acoustic stressors associated with training and testing activities throughout the year. Blue whales are expected to experience AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic coast from AFTT sonar and explosives. Based on the quantitative acoustic effects analysis (i.e., NAEMO), 12 instances of behavioral harassment, 59 instances of TTS, and up to one instance of AINJ are reasonably certain to occur annually, in a maximum year of AFTT sonar and explosive activities. As described in greater detail in Section 6.1.1, we do not anticipate these instances of TTS or behavioral harassment to result in long-term fitness consequences affecting the reproduction or survival of blue whales. Any

adverse effects resulting from TTS or behavioral responses are expected to be relatively minor and short-term.

Unlike TTS, AINJ could be permanent (e.g., PTS), meaning the effects last well beyond the duration of the action and outside of the action area as animals migrate. As such, PTS has the potential to affect aspects of the affected animal's life functions that do not overlap in time and space with the action. From our effects analysis we estimate up to one instance of blue whale AINJ annually, but, as discussed in more detail in Section 6.1.1, the magnitude of this impairment is expected to be minor due to the methodology used to calculate impacts and the Action Proponents' proposed mitigation. With this anticipated minor degree of AINJ (i.e., mild severity PTS), even though a small number of blue whales are expected to experience a minor reduction in fitness, we would not expect such impacts to have meaningful effects at the population level. That is, individual whales affected could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of AINJ will result in changes in the number, distribution, or reproductive potential of blue whales in the Western Atlantic Ocean or range wide.

Long-term or chronic physiological stress responses that could potentially result in fitness consequences are not anticipated to occur in blue whales given the types of AFTT sonar systems proposed and the dispersed nature of sonar use in space and time. Blue whales exposed to military sonar can experience masking if the sonar interferes with the animal's ability to communicate with conspecifics or detect biologically relevant sounds. In most instances masking would be limited since it could only occur if there is overlap between the sonar sound source frequencies and the low frequency blue whale vocalizations. In addition, since masking only occurs in the presence of the masking noise, most instances would be minor and short-term, with no appreciable impacts to the fitness of individual blue whales. However, blue whales will likely be exposed to continuous active sonar (MF1C) at levels that could result in masking effects that are longer lasting compared to pulsed active sonar (MF1). While this could lead to behavioral disruptions affecting communication and social interactions, based on our exposure analysis we expect, at most, only a few instances of masking from continuous active sonar per individual blue whale annually.

Based on the best available information, no non-auditory injury or mortality of this species is anticipated from AFTT activities involving sonar or explosives. Additionally, no vessel strike of blue whales is anticipated.

The 2020 blue whale recovery plan (NMFS 2020b) outlines downlisting and delisting criteria, which include increasing blue whale resiliency and ensuring geographic and ecological representation, minimizing anthropogenic effects, and ensuring anthropogenic activities are not contributing to the species being in danger of extinction within the foreseeable future throughout all or a significant portion of its range. The recovery plan lists several stressors potentially affecting the status of blue whales in the Western Atlantic Ocean that are relevant to AFTT

activities including vessel strike, vessel disturbance, and military operations. No appreciable reduction in the number of blue whales is expected to occur from the action. Because we do not anticipate long-term fitness consequences to individual blue whales to result from the proposed action, we do not expect the proposed action to result in reductions in the overall reproduction, abundance, or distribution of the blue whale population in the North Atlantic Ocean or range-wide.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponents will conduct in the AFTT action area on an annual basis, cumulatively over the 7-year MMPA rule, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of blue whales in the wild by reducing the reproduction, numbers, or distribution of this species. Similarly, the effects from ongoing AFTT activities and related incidental take specified in the MMPA rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of blue whales in the wild. Thus, we determine that the action would not appreciably reduce the likelihood of both survival and recovery of blue whales in the wild.

8.1.3 Fin Whale

The best available current abundance estimate for fin whales in the Western North Atlantic stock (from Florida to Newfoundland/Labrador) is 6,802 (Hayes et al. 2023). The available information does not support a population trend analysis for this stock. The range wide species abundance is in the tens of thousands distributed across major ocean basins and hemispheres.

Fin whales are expected to experience AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic Coast from AFTT sonar, air guns and explosives. Based on the quantitative acoustic effects analysis (i.e., NAEMO), 689 instances of behavioral harassment, 1,927 instances of TTS, and 21 instances of AINJ are reasonably certain to occur annually, in a maximum year of AFTT sonar, air gun, and explosive activities. Based on the best available information, no non-auditory injury or mortality of this species is anticipated from AFTT activities involving sonar, air guns, or explosives.

As described in greater detail in Sections 6.1.1, we do not anticipate these instances of TTS or behavioral harassment to result in long-term fitness consequences affecting the reproduction or survival of fin whales. Any adverse effects resulting from TTS or behavioral responses are expected to be relatively minor and short-term. Unlike TTS, AINJ could be permanent (e.g., PTS), meaning the effects last well beyond the duration of the action and outside of the action area as animals migrate. Permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. As described in

more detail in Section 6.1.1, while we anticipate that most fin whale AINJ exposures resulting from the proposed action would be of relatively mild severity, a small number of PTS exposures could result in more severe incidents of PTS, with greater fitness consequences for those individual fin whales exposed. The available information does not allow us to quantify the proportion of fin whale AINJ resulting from the proposed action that will result in mild, moderate or high severity PTS. Individual fin whales with a minor degree of AINJ could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. Moderate to high severity PTS could result in more consequential, long-term fitness impacts to individual fin whales exposed. However, such instances of moderate to high severity PTS are expected to be rare, and will likely only impact a very small number of fin whales relative to the population size. For this reason, we do not anticipate that instances of AINJ will result in appreciable changes in the number, distribution, or reproductive potential of fin whales in the Western Atlantic Ocean or throughout their range.

Similarly, the long-term or chronic physiological stress responses that could potentially result in fitness consequences are not anticipated to occur in fin whales given the types of AFTT sonar systems proposed and the dispersed nature of sonar use in space and time. Fin whales exposed to military sonar can experience masking if the sonar interferes with the animal's ability to communicate with conspecifics or detect biologically relevant sounds. However, masking would be limited for fin whales since it could only occur if there is overlap between the sonar sound source frequencies and the low frequency fin whale vocalizations. In addition, since masking only occurs in the presence of the masking noise, most instances would be minor and short-term, with no appreciable impacts to the fitness of individual fin whales. However, fin whales will likely be exposed to continuous active sonar (MF1C) at levels that could result in masking effects that are longer lasting compared to pulsed active sonar (MF1). While this could lead to behavioral disruptions affecting communication and social interactions, based on our exposure analysis we expect, at most, only a few instances of masking from continuous active sonar per individual fin whale annually.

From our vessel strike analysis (Section 6.1.2), we anticipate Action Proponent vessels will strike up to two fin whales over the 7-year period of the proposed MMPA rule, and during each subsequent 7-year period into the reasonably foreseeable future. Death would result in the loss of reproductive potential that the individual might have contributed to the population or subpopulation. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual, with the loss of a mature female potential being more consequential to the population. Best available information suggests the fin whale population occurring in the Atlantic Ocean portion of the action area consists of 6,802 animals. Assuming a balanced sex ratio, this means there are about 3,401 females in the population. If the two fin whales that are expected to be struck over seven years are both females of early reproductive age, this would only reduce the reproductive potential of the Western North Atlantic stock by

0.06% (note: this is considered an overestimate since some fin whale vessel strikes will likely be of males). This is not an appreciable reduction in the numbers or the reproductive capability of fin whales in the Atlantic Ocean portion of the action area. The impact of this level of vessel strike would be even less consequential for the range-wide fin whale species population. Therefore, we conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of the species in the AFTT action area or range wide. If the analyzed rate of vessel strike for this species was to recur in subsequent 7-year periods into the reasonably foreseeable future, based on the available information and this calculated rate of reduction in reproductive potential, we also believe it is unlikely that there would be an appreciable reduction to survival or reproduction rates or the species' ability to recover. In addition, the relatively small loss of reproductive potential resulting from vessel strike would not affect the current geographic range of fin whales, and no reduction in the distribution of this species is expected as a result of the action.

The 2010 fin whale recovery plan includes the following downlisting criteria: 1) Factors that may limit population growth have been identified and are being or have been addressed to the extent that they allow for continued growth of populations in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere), and 2) The population in each ocean basin satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) and has at least 500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males) (NMFS 2010b). In the latest 5-year review (NMFS 2019c), NMFS recommended that the fin whale be downlisted from endangered to threatened based on meeting the downlisting criteria. As discussed above, we do not anticipate that the threats to fin whales (i.e., AINJ, TTS, behavioral response, and physiological stress from acoustic stressors, and vessel strike) resulting from the action would appreciably limit the growth of the Western North Atlantic stock.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponents will conduct in the AFTT action area on an annual basis, cumulatively over the 7-year MMPA rule, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of fin whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities and related incidental take specified in the MMPA rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of fin whales in the wild. Thus, we determine that the action would not appreciably reduce the likelihood of both survival and recovery of fin whales in the wild.

8.1.4 Sei Whale

Sei whales affected by the proposed action would be from the Nova Scotia stock, which includes the U.S. Atlantic Coast through Cape Breton, Nova Scotia (Hayes et al. 2023). The best estimate of abundance for the Nova Scotia stock sei whales is 6,292 (Hayes et al. 2023). The available information does not support a population trend analysis for this stock.

Sei whales are expected to experience AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic Coast from AFTT sonar and explosives. Based on the quantitative acoustic effects analysis (i.e., NAEMO), 125 instances of behavioral harassment, 622 instances of TTS, and seven instances of AINJ are reasonably certain to occur annually, in a maximum year of AFTT sonar and explosive activities. Based on the best available information, non-auditory injury or mortality of this species is not anticipated from AFTT activities involving sonar or explosives.

As described in greater detail in Sections 6.1.1, we do not anticipate these instances of TTS or behavioral harassment to result in long-term fitness consequences affecting the reproduction or survival of sei whales. Any adverse effects resulting from TTS or behavioral responses are expected to be relatively minor and short-term. Unlike TTS, AINJ could be permanent (e.g., PTS), meaning the effects last well beyond the duration of the action and outside of the action area as animals migrate. Permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. As discussed above for blue whales and described in more detail in Section 6.1.1, we anticipate that sei whale AINJ exposures resulting from the proposed action would be of relatively mild severity. With this minor degree of AINJ (i.e., mild severity PTS), individual sei whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of AINJ will result in changes in the number, distribution, or reproductive potential of sei whales in the Western Atlantic Ocean or range wide.

Long-term or chronic physiological stress responses that could potentially result in fitness consequences are not anticipated to occur in sei whales given the types of AFTT sonar systems proposed and the dispersed nature of sonar use in space and time. Sei whales exposed to military sonar can experience masking if the sonar interferes with the animal's ability to communicate with conspecifics or detect biologically relevant sounds. However, masking would be limited for sei whales since it could only occur if there is overlap between the sonar sound source frequencies and the low frequency fin whale vocalizations. In addition, since masking only occurs in the presence of the masking noise, most instances would be minor and short-term, with no appreciable impacts to the fitness of individual sei whales. However, sei whales will likely be exposed to continuous active sonar (MF1C) at levels that could result in masking effects that are longer lasting compared to pulsed active sonar (MF1). While this could lead to behavioral disruptions affecting communication and social interactions, based on our exposure analysis we

expect, at most, only a few instances of masking from continuous active sonar per individual sei whale annually.

From our vessel strike analysis (Section 6.1.2), we anticipate Action Proponent vessels will strike up to two sei whales over the 7-year period of the proposed MMPA rule, and during each subsequent 7-year period into the reasonably foreseeable future. Death would result in the loss of reproductive potential that the individual might have contributed to the population or subpopulation. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual, with the loss of a mature female potential being more consequential to the population. Best available information suggests the sei whale population occurring in the Atlantic Ocean portion of the action area consists of 6,292 animals. Assuming a balanced sex ratio, this means there are about 3,146 females in the population. If the two sei whales that are expected to be struck over seven years are both females of early reproductive age, this would only reduce the reproductive potential of the Western North Atlantic stock by 0.06% (note: this is considered an overestimate since some sei whale vessel strikes will likely be of males). This is not an appreciable reduction in the numbers or the reproductive capability of sei whales in the Atlantic Ocean portion of the action area. The impact of this level of vessel strike would be even less consequential for the range-wide sei whale species population. Therefore, we conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of the species in the AFTT action area or range wide. If the analyzed rate of vessel strike for this species was to recur in subsequent 7-year periods into the reasonably foreseeable future, based on the available information and this calculated rate of reduction in reproductive potential, we also believe it is unlikely that there would be an appreciable reduction to survival or reproduction rates or the species' ability to recover. In addition, the relatively small loss of reproductive potential resulting from vessel strike would not affect the current geographic range of sei whales, and no reduction in the distribution of this species is expected as a result of the action.

Based on the 2011 sei whale recovery plan (NMFS 2011a), downlisting criteria (i.e., from endangered to threatened) include: populations in each ocean basin (North Atlantic, North Pacific and Southern Hemisphere) that have no more than a 1% chance of extinction in 100 years; the global population has at least 1,500 mature, reproductive individuals, consisting of at least 250 mature females and at least 250 mature males in each ocean basin; and none of the known threats to sei whales are known to limit the continued growth of populations. For delisting consideration, in addition to the above, the total sei whale abundance in each ocean basin must have less than a 10% probability of becoming endangered in 20 years. As discussed above, we do not anticipate that the threats to sei whales (i.e., AINJ, TTS, behavioral response, and physiological stress from acoustic stressors, and vessel strike) resulting from the action would appreciably limit the growth of the Western North Atlantic stock.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponents will conduct in the AFTT action area on an annual basis,

cumulatively over the 7-year MMPA rule, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of sei whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities and related incidental take specified in the MMPA rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of sei whales in the wild. Thus, we determine that the action would not appreciably reduce the likelihood of both survival and recovery of sei whales in the wild.

8.1.5 Rice's Whale

The current best available abundance estimate for the Rice's whale is 51 animals, with a confidence interval of 20 to 130 whales (Garrison et al. 2020) and a minimum population estimate of 34 (NMFS 2021f). Given the very small population size, available information is insufficient to effectively monitor trends in Rice's whale abundance over time. Nearly one-half of the Rice's whale population was exposed to the DWH oil spill, resulting in increased estimated rates of mortality (17%) and failed pregnancies (22%)(DWH-MMIQT 2015). The most significant ongoing anthropogenic threats to the species are sound, vessel strike, energy exploration, and oil spills (Rosel 2016).

Rice's whales are expected to experience AINJ, TTS, behavioral and physiological stress responses throughout waters off the Gulf of America from AFTT sonar and explosives. Based on the quantitative acoustic effects analysis (i.e., NAEMO), 88 instances of behavioral harassment, 215 instances of TTS, and up to three instances of AINJ are reasonably certain to occur annually, in a maximum year of AFTT sonar and explosive activities. Based on the best available information, no non-auditory injury or mortality of this species is anticipated from AFTT activities involving sonar or explosives. Additionally, no vessel strike of Rice's whales is anticipated (see Section 6.1.2 for details).

As described in greater detail in Sections 6.1.1, we do not anticipate these instances of TTS or behavioral harassment to result in long-term fitness consequences affecting the reproduction or survival of Rice's whales. Although an income breeding strategy may make Rice's whales more susceptible to repeated short-term foraging losses over time, any adverse effects resulting from TTS or behavioral responses are expected to be relatively minor and short-term. While energetic costs to exposed individuals may be greater during large-scale military events that occur over multiple days (to weeks), over large ocean areas, and involve multiple sonar platforms, no MTEs or coordinated/integrated exercises are planned for areas that overlap with Rice's whale habitat. Typical activities occurring within Rice's whale habitat consist of a single platform, testing sonar capabilities, with the activity and sonar use spread out in space and time. For this reason, Rice's whales that are exposed to sonar and other transducers will be exposed episodically over certain months or seasons when the Navy is conducting testing activities using sonar in the eastern Gulf

of America. Due to the limited number of AFTT activities conducted in the Gulf of America that are expected to result in harassment of this species, the relatively short duration of these exercises (i.e., no MTEs or coordinated/integrated exercises planned), and that both the sonar platform and the animal would be moving, we do not anticipate long duration exposures or exposures to individual Rice's whales that recur on subsequent days.

Whereas most large whales (including those considered in this opinion) exhibit migratory movement patterns, Rice's whales are a resident species within the Gulf of America, where they live year-round. The exposure potential for resident species is year-round and the risk of repeated impacts on individuals is likely similar within the population as animals move throughout their range (Keen et al. 2021). From our acoustic and explosives effects exposure analysis, the average annual number of exposures resulting in TTS or a significant behavioral response per individual Rice's whale is 2.6 (assuming a maximum year of activity levels). While some individual whales may be exposed more often than the average (and some less), based on the available information, it is unlikely that any Rice's whale would have TTS or a significant behavioral response more than 10 times in a given year. The relatively small number of instances per year, and amount of time per instance, that a Rice's whale suffer TTS or have a significant behavioral response as a result of the proposed action provides further support for our conclusion that these impacts would not result in long-term fitness consequences.

Unlike TTS, AINJ could be permanent (e.g., PTS), meaning the effects last well beyond the duration of the action and outside of the action area as animals migrate. Permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. As described in more detail in Section 6.1.1, we anticipate that Rice's whale AINJ exposures resulting from the proposed action would be of relatively mild severity. The proposed mitigation measures, including the prohibition on using in-water explosives (except for mine warfare activities) within the core Rice's whale use mitigation area, and small number of AINJ anticipated (i.e., six total instances every seven years; one from explosives, five from sonar) further reduce the likelihood of a moderate to severe instance of AINJ. Individual Rice's whales exposed to a minor degree of AINJ (i.e., mild severity PTS), could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of AINJ will result in changes in the number, distribution, or reproductive potential of Rice's whales in the Gulf of America.

Rice's whales exposed to military sonar can experience masking if the sonar interferes with the animal's ability to communicate with conspecifics or detect biologically relevant sounds. However, masking would be limited for Rice's whales since it could only occur if there is overlap between the sonar sound source frequencies and the low frequency Rice's whale vocalizations. In addition, since masking only occurs in the presence of the masking noise, most instances would be minor and short-term, with no appreciable impacts to the fitness of individual

Rice's whales. Similarly, the long-term or chronic physiological stress responses that could potentially result in fitness consequences are not anticipated to occur given the types of AFTT sonar systems proposed and the dispersed nature of sonar use in space and time.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponents will conduct in the AFTT action area on an annual basis, cumulatively over the 7-year MMPA rule, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of Rice's whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities and related incidental take specified in the MMPA rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of Rice's whales in the wild. Thus, we determine that the action would not appreciably reduce the likelihood of both survival and recovery of Rice's whales in the wild.

8.1.6 Sperm Whale

The current global sperm whale estimate is about 850,000 whales (Whitehead and Shin 2022). There are no reliable estimates for sperm whale abundance across the entire North Atlantic Ocean. The best abundance estimate available for the portion of the North Atlantic sperm whale stock that overlaps with the AFTT action area, based on 2021 survey data from Central Florida to the lower Bay of Fundy, is 5,895 (Hayes et al. 2023). A population trend is not available for the North Atlantic sperm whale stock. The best abundance estimate for the northern Gulf of Mexico stock is 1,180 (Garrison et al. 2020; Hayes et al. 2021). Garrison et al. (2020) found no significant differences in abundance estimates across multiple survey years (i.e., 2003 to 2004, 2009, and 2017 to 2018), suggesting a stable sperm whale population trend in U.S. Gulf of America waters over this time period. However, the statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long intervals between surveys (Hayes et al. 2021). Frasier et al. (2024a) documented a 31% density decline for sperm whales in the northeastern Gulf of America in the decade after the Deepwater Horizon oil spill. There are insufficient data to estimate abundance or trends for the Puerto Rico and U.S. Virgin Islands sperm whale stock.

Sperm whales are expected to experience non-auditory injury, AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic Coast and in the Gulf of America from AFTT sonar and explosives. Based on the quantitative acoustic effects analysis (i.e., NAEMO), 9,126 instances of behavioral harassment, 3,739 instances of TTS, six instances of AINJ, and up to one instance of non-auditory injury are reasonably certain to occur annually to sperm whales, in a maximum year of AFTT activities. Based on the best available information, no mortality of this species is anticipated from AFTT activities involving sonar or explosives.

As described in greater detail in Sections 6.1.1 do not anticipate these instances of TTS or behavioral harassment to result in long-term fitness consequences affecting the reproduction or survival of sperm whales. Any adverse effects resulting from TTS or behavioral responses are expected to be relatively minor and short-term. Unlike TTS, AINJ could be permanent (e.g., PTS), meaning the effects last well beyond the duration of the action and outside of the action area as animals migrate. Permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. As described in more detail in Section 6.1.1, while we anticipate that most sperm whale AINJ exposures resulting from the proposed action would be of relatively mild severity, a small number of PTS exposures could result in more severe incidents of PTS, with greater fitness consequences for those individual sperm whales exposed. The available information does not allow us to quantify the proportion of sperm whale AINJ resulting from the proposed action that will result in mild, moderate or high severity PTS. Individual sperm whales with a minor degree of AINJ could be less efficient at locating conspecifics or prey using echolocation, or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, find prey, and detect threats with enough time to avoid injury. Moderate to high severity PTS could result in more consequential, long-term fitness impacts to individual sperm whales exposed. However, such instances of moderate to high severity PTS are expected to be rare, and will likely only impact a very small number of sperm whales relative to the population size. For this reason, we do not anticipate that instances of AINJ will result in appreciable changes in the number, distribution, or reproductive potential of sperm whales in the Atlantic Ocean, Gulf of America or throughout their range.

Long-term or chronic physiological stress responses that could potentially result in fitness consequences are not anticipated to occur in sperm whales given the types of AFTT sonar systems proposed and the dispersed nature of sonar use in space and time. Sperm whales exposed to military sonar can experience masking if the sonar interferes with the animal's ability to communicate with conspecifics or detect biologically relevant sounds. Since masking only occurs in the presence of the masking noise, most instances would be minor and short-term, with no appreciable impacts to the fitness of individual sperm whales. While masking of echolocation clicks could result in sperm whales being less efficient at locating prey, we expect that the lost foraging opportunities would be short-term with the animals returning to normal feeding efficiency once the sound source is gone. However, newer high duty cycle or continuous active sonar systems have more potential to mask vocalizations, particularly for mid-frequency cetaceans (e.g., sperm whales) given the overlap in vocalization frequency with these sonar systems. Sperm whales will likely be exposed to continuous active sonar (MF1C) at levels that could result in masking effects that are longer lasting compared to pulsed active sonar (MF1). While the lower source levels of these systems limit the range of impact compared to more traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. While this could lead to behavioral

disruptions affecting foraging, communication, social interactions, based on our exposure analysis we expect, at most, only a few instances of masking from continuous active sonar per individual sperm whale annually.

As discussed above (Section 6.1.1), we expect that sperm whales experiencing a non-auditory injury would be temporarily impaired as a result. While recovering from its injury, we assume the animal's ability to conduct important life functions (e.g., breeding, feeding) would be diminished, but that the animal would survive. For a slight lung injury, which defines the threshold for onset of non-auditory injury, it is reasonable to assume the whale would recover within several months. A more severe injury could take longer until full recovery, which could result in a decrease in the animal's reproductive potential, particularly if it occurs to a mature female. However, given their long life spans, it is unlikely that a single injury would result in a significant impact on the life-time reproductive potential of an individual sperm whale. Since non-auditory injuries are expected to occur rarely (i.e., less than one every seven years), it is extremely unlikely that the same individual sperm whale will be exposed to such an injury more than once as a result of the AFTT proposed action.

From our vessel strike analysis (Section 6.1.2), we anticipate Action Proponent vessels will strike up to two sperm whales over the seven year period of the proposed MMPA rule, and during each subsequent seven year period into the reasonably foreseeable future. Death would result in the loss of reproductive potential that the individual might have contributed to the population or subpopulation. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual with the loss of a female potentially being more consequential to the population. Best available information suggests the sperm whale population occurring in the North Atlantic Ocean and Gulf of America portion of the action area consists of 5,895 and 1,180 animals, respectively. Assuming a balanced sex ratio, this means there are about 2,948 females in the Atlantic population and 590 females in the Gulf of America population. As discussed in our large vessel strike analysis in Section 6.1.2, if the Navy or Coast Guard were to strike an ESA-listed sperm whale there is a very high probability that this would occur within the Atlantic Ocean portion of the action area based on historical strikes and the proposed level of vessel activity in the Atlantic versus the Gulf of America. As such, it is a reasonable assumption that both strikes could be of North Atlantic stock sperm whales. If the two sperm whales that are expected to be struck over seven years are both females of early reproductive age, this would only reduce the reproductive potential of the North Atlantic stock by 0.07% every seven years (note: this is considered an overestimate since some sperm whale vessel strikes will likely be of males). If one female sperm whale strike is from the Gulf of Mexico stock (i.e., based on our analysis we assume that both strikes will not be from this stock), the reproductive potential of this stock would be reduced by 0.17% every seven years. These estimated changes in reproductive potential do not represent an appreciable reduction in the numbers or the reproductive capability of sperm whales in the Atlantic Ocean or Gulf of America portions of the action area. The impact of this level of vessel strike would be even less consequential for the range-wide sperm whale species population, which includes several hundred thousand whales.

Therefore, we conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of the species in the AFTT action area or range wide. If the analyzed rate of vessel strike for this species was to recur in subsequent 7-year periods into the reasonably foreseeable future, based on the available information and this calculated rate of reduction in reproductive potential, we also believe it is unlikely that there would be an appreciable reduction to survival or reproduction rates or the species' ability to recover. In addition, the relatively small loss of reproductive potential resulting from vessel strike would not affect the current geographic range of sperm whales, and no reduction in the distribution of this species is expected as a result of the action.

The 2010 sperm whale recovery plan defines three recovery populations by ocean basin (the Atlantic Ocean/Mediterranean Sea, Pacific Ocean, and Indian Ocean) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, changing environmental conditions, direct harvest, oil spills, anthropogenic noise, and vessel strike. Of these, anthropogenic noise and ship collision are relevant to AFTT activities. Downlisting criteria for sperm whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population. As discussed above, we do not anticipate that the threats to sperm whales (i.e., non-auditory injury, AINJ, TTS, behavioral response, and physiological stress from acoustic stressors, and vessel strike) resulting from the action would appreciably limit the growth of the North Atlantic or Gulf of Mexico stocks.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponents will conduct in the AFTT action area on an annual basis, cumulatively over the 7-year MMPA rule, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of sperm whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities and related incidental take specified in the MMPA rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of sperm whales in the wild. Thus, we determine that the action would not appreciably reduce the likelihood of both survival and recovery of sperm whales in the wild.

8.1.7 Green Sea Turtle – North Atlantic DPS

The North Atlantic DPS exhibits the highest nesting abundance of all green sea turtle populations with approximately 167,424 females across 73 nesting sites (Seminoff et al. 2015). Although there are no reliable estimates of population growth rate for the DPS as a whole, the available data indicate that all major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015).

North Atlantic DPS green sea turtles are expected to experience mortality, non-auditory injury, AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic

Coast and in the Gulf of America from AFTT sonar, air guns, and explosives. The quantitative acoustic effects analysis (i.e., NAEMO) predicts 3,962 instances of behavioral harassment, 8,251 instances of TTS, and 68 instances of AINJ, up to three instances of non-auditory injury, and up to one mortality are reasonably certain to occur annually, in a maximum year of AFTT sonar, air guns and explosives activities.

As discussed in Section 6.2.1, a non-auditory injury can impact an individual sea turtle's fitness, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. Depending on the type of injury (e.g., severity, location) and other relevant factors (e.g., animal life stage, size, condition prior to exposure), a reduction in fitness from non-auditory injury could either be temporary with recoverable impacts, or result in long-term fitness consequences for some individuals. While long-term fitness consequences could affect population growth, the quantitative analysis estimated a relatively small number (i.e., up to three per year) of non-auditory injuries to green sea turtles. Considering the size of the population, any such fitness impacts would not result in an appreciable reduction in the reproductive potential or growth rate of the North Atlantic DPS of green sea turtles.

Auditory injury in the form of PTS could decrease an individual sea turtle's ability to detect danger such as approaching vessels or predators; and may reduce foraging or breeding opportunities or increase risks of sustaining other harm. While some proportion of green sea turtle PTS exposures could result in minor fitness consequences, sea turtles, in general, are not considered to rely extensively on their hearing for important life functions (Popper et al. 2014; Nelms et al. 2016). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions.

We have no information to suggest that TTS in sea turtles would result in fitness consequences to individuals or the populations to which they belong. Similarly, behavioral and physiological responses to acoustic stressors are expected to be temporary and episodic, with no reduction in fitness of individual turtles. Any adverse effects to sea turtles resulting from TTS or behavioral responses are expected to be relatively minor and short-term.

Based on our sea turtle vessel strike exposure analysis (Section 6.2.2), we estimate there would be 38 lethal vessel strikes of North Atlantic DPS green sea turtles annually due to the proposed action. The NAEMO acoustic effects analysis also predicted one North Atlantic DPS green sea turtle mortality annually resulting from explosives use for Navy training. Since some of the turtles killed by vessel strike or explosives will likely be females, the action may result in a reduction in the reproductive potential of this species. Loss of a sexually mature female will have immediate effects on recruitment, while future lost reproductive potential from mortality of a juvenile female might not be realized for several years. From our exposure analysis (Section 6.2.2), we anticipate that approximately two-thirds of the green sea turtle vessel strikes will be females. The loss of 27 (i.e., 26 from vessel strike and one from explosives) female North Atlantic DPS green sea turtles is likely to exert some effect on the population numbers in the near-term in the action area. However, the anticipated mortality from vessel strikes is not likely

to impact the survival and recovery of the DPS, as this level of mortality represents a small fraction (0.02% annually) of the estimated 167,424 adult nesting females (conservatively assuming all females struck would be adults) in the population. We do not consider this to be an appreciable reduction in the numbers of female North Atlantic DPS green sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. The anticipated loss of current and future reproductive potential is relatively small compared to the population size, and would have a negligible effect on the recent increasing trend in nesting abundance reported for this DPS. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of the North Atlantic DPS green sea turtle, we do not expect this level of mortality to impact the survival or recovery of this population. In addition, the relatively small loss of reproductive potential resulting from vessel strikes will not affect the current geographic range of this DPS, and no reduction in the distribution of this DPS is expected as a result of the action.

NMFS and USFWS (1991) identified the major actions needed to recover the U.S. Atlantic population of green sea turtles. Recovery criteria for delisting the North Atlantic DPS include the following: 1) the level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years; 2) at least 25% (105 km) of all available nesting beaches (420 km) is in public ownership and encompasses greater than 50% of the nesting activity; and 3) a reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds. While we do anticipate North Atlantic DPS green sea turtle mortalities from vessel strike, and injuries (some with fitness consequences) from both vessel strike and acoustic stressors, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of this population of green sea turtles. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this population.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of North Atlantic DPS green sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of North Atlantic DPS green sea turtles in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of North Atlantic DPS green sea turtles in the wild.

8.1.8 Hawksbill Sea Turtle

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, sub-tropical waters of the Atlantic, Indian, and Pacific Oceans. Based on the best available information, approximately 25,000 female hawksbill sea turtles nest each year throughout these three ocean basins (NMFS 2013c). Nesting within the action area occurs in Puerto Rico, and to a

lesser extent in south Florida and the Florida Keys. Hawksbills are in general considered extralimital north of Florida and, therefore, this species is not expected to overlap with the large majority of military readiness activities and associated stressors in the AFTT action area.

Hawksbill sea turtles are expected to experience AINJ, TTS, behavioral and physiological stress responses in the Gulf of America and south Florida as a result of the proposed action. As discussed in Section 6.2.1, we use a surrogate for impacts to hawksbill sea turtles since we could not quantify impacts based on the available information. Given the small spatial overlap between hawksbill occurrence and AFTT activities, we anticipate a relatively small number of annual hawksbill exposures to sonar and explosives will result in adverse effects including AINJ, TTS, significant behavioral response, and associated physiological stress responses. No hawksbill mortalities or non-auditory injuries are anticipated as a result of sonar and explosives due to the anticipated low species' density and small spatial overlap (i.e., Gulf of America and south Florida) between the species' range and where most AFTT activities would occur.

Auditory injury in the form of PTS could decrease an individual sea turtle's ability to detect danger such as approaching vessels or predators; and may reduce foraging or breeding opportunities or increase risks of sustaining other harm. While some proportion of hawksbill sea turtle PTS exposures could result in minor fitness consequences, sea turtles, in general, are not considered to rely extensively on their hearing for important life functions (Popper et al. 2014; Nelms et al. 2016). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions.

We have no information to suggest that TTS in sea turtles would result in fitness consequences to individuals or the populations to which they belong. Similarly, behavioral and physiological responses to acoustic stressors are expected to be temporary and episodic, with no reduction in fitness of individual turtles. Any adverse effects to sea turtles resulting from TTS or behavioral responses are expected to be relatively minor and short-term.

Based on our sea turtle vessel strike exposure analysis (Section 6.2.2), we anticipate a very small number of hawksbill sea turtle lethal vessel strikes due to the proposed action (i.e., about one every seven years). Since some of the turtles killed by vessel strike will likely be females, the action may result in a slight reduction in the reproductive potential of this species. Loss of a sexually mature female will have immediate effects on recruitment, while future lost reproductive potential from the mortality of a juvenile female might not be realized for several years. However, with a global nesting population size of about 25,000 females, the loss of one turtle every seven years does not represent an appreciable reduction in the numbers of female hawksbill sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. The anticipated loss of current and future reproductive potential is relatively small compared to the population size, and would have a negligible effect on the recent increasing trend in nesting abundance reported for this DPS. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of hawksbill sea turtles, we do not expect this level of mortality to

impact the survival or recovery of this population. In addition, the relatively small loss of reproductive potential resulting from vessel strike will not affect the current geographic range of this species, and no reduction in the distribution of this species is expected as a result of the action.

The NMFS recovery plan (NMFS and USFWS 1993) identified the major actions needed to recover the U.S. Atlantic population of hawksbill sea turtles. Relevant to the proposed action, these included ensuring long-term protection of important foraging habitats. Criteria for delisting the U.S. hawksbill population include 25-year increasing trends in the adult female nester population on five index beaches, and adult, subadult, and juvenile abundance in key foraging areas within Puerto Rico, USVI, and Florida. While we do anticipate a very small number of hawksbill mortalities from vessel strike and injuries (some with fitness consequences) from both vessel strike and acoustic stressors, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of hawksbill sea turtles. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this species.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of hawksbill sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of hawksbill sea turtles in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of hawksbill sea turtles in the wild.

8.1.9 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle has declined to the lowest population level of all sea turtle species in the world. Nesting aggregations at a single location (Rancho Nuevo, Mexico), which were estimated at 40,000 females in 1947, declined to an estimated 300 females by the mid-1980s. From 1980 through 2003, largely due to conservation efforts, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico increased 15% annually (Heppell et al. 2005). By 2014 there were an estimated 10,987 nests and 519,000 hatchlings released from these three primary nesting beaches. Since females lay approximately 2.5 nests each season they nest, 10,987 nests represents 4,395 females nesting in a season at these primary nesting sites. Increases in nest counts have also been documented over the past two decades at nesting beaches in Texas (NMFS and USFWS 2015). DiMatteo et al. (2024) modeled survey data to estimate an in-water abundance of juvenile and adult Kemp's ridley sea turtles (> 40 cm) along the U.S. Atlantic Coast of 10,762 turtles.

Kemp's ridley sea turtles are expected to experience non-auditory injury, AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic Coast and in the Gulf of

America from AFTT sonar, air guns, and explosives. The quantitative acoustic effects analysis (i.e., NAEMO) predicts 7,140 instances of behavioral harassment, 9,227 instances of TTS, 62 instances of AINJ, and two non-auditory injury are reasonably certain to occur annually, in a maximum year of AFTT sonar, air guns and explosives activities.

As discussed in Section 6.2.1, a non-auditory injury can impact an individual sea turtle's fitness, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. Depending on the type of injury (e.g., severity, location) and other relevant factors (e.g., animal life stage, size, condition prior to exposure), a reduction in fitness from non-auditory injury could either be temporary with recoverable impacts, or result in long-term fitness consequences for some individuals. While long-term fitness consequences could affect population growth, the quantitative analysis estimated a very small number (i.e., up to two per year) of non-auditory injuries to Kemp's ridley sea turtles. Considering the size of the population, any such fitness impacts to such a small number of turtles would not result in an appreciable reduction in the reproductive potential or growth rate of the Kemp's ridley sea turtles population.

Auditory injury in the form of PTS could decrease an individual sea turtle's ability to detect danger such as approaching vessels or predators; and may reduce foraging or breeding opportunities or increase risks of sustaining other harm. While some proportion of Kemp's ridley sea turtle PTS exposures could result in minor fitness consequences, sea turtles, in general, are not considered to rely extensively on their hearing for important life functions (Popper et al. 2014; Nelms et al. 2016). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions.

We have no information to suggest that TTS in sea turtles would result in fitness consequences to individuals or the populations to which they belong. Similarly, behavioral and physiological responses to acoustic stressors are expected to be temporary and episodic, with no reduction in fitness of individual turtles. Any adverse effects to sea turtles resulting from TTS or behavioral responses are expected to be relatively minor and short-term.

Based on our sea turtle vessel strike exposure analysis (Section 6.2.2), we estimate there would be eight lethal vessel strikes of Kemp's ridley sea turtles annually due to the proposed action. Since some of the turtles killed by vessel strike will likely be females, the action may result in a reduction in the reproductive potential of this species. Loss of a sexually mature female will have immediate effects on recruitment, while future lost reproductive potential from mortality of a juvenile female might not be realized for several years. From our exposure analysis (Section 6.2.2) we anticipate that approximately 61% of the Kemp's ridley sea turtle vessel strikes will be females. The loss of five female Kemp's ridley sea turtles is likely to exert some effect on the population numbers in the near-term in the action area. However, this anticipated mortality level is not likely to impact the survival and recovery of this species, as these levels of mortality represent a relatively small fraction (0.11% annually) of the estimated adult female population. This is a conservative estimate of the proportional reproductive potential lost, since it assumes all females struck would be adult, and is based on the estimated number of nesting females in a

given year (i.e., not all mature females nest every year), and only females at the primary nesting sites (NMFS and USFWS 2015). We do not consider this to be an appreciable reduction in the numbers of female Kemp's ridley sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of the Kemp's ridley sea turtle, we do not expect this level of mortality to impact the survival or recovery of this population. In addition, the relatively small loss of reproductive potential resulting from vessel strike will not affect the current geographic range of this species, and no reduction in the distribution of this species is expected as a result of the proposed action.

The 2011 Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle identified the major actions needed to recover this species (NMFS et al. 2011). Relevant to the proposed action, these include minimize vessel strike mortality and ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing at a greater rate than strandings of similar age classes. Demographic recovery criteria for downlisting the species include the following: 1) a population of at least 10,000 nesting females in a season (as measured by clutch frequency per female per season) distributed at the primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico; and 2) recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches. While we do anticipate Kemp's ridley sea turtle mortalities from vessel strike, and injuries (some with fitness consequences) from both vessel strike and acoustic stressors, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of this population of Kemp's ridley sea turtles. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this species.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of Kemp's ridley sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of Kemp's ridley sea turtles in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of Kemp's ridley sea turtles in the wild.

8.1.10 Loggerhead Sea Turtle – Northwest Atlantic DPS

While an overall estimate of nesting females for the Northwest Atlantic Ocean DPS is not available, based on available nest count data from Texas through Virginia and Quintana Roo, Mexico, the DPS hosts more than 110,000 nests annually (NMFS and USFWS 2023). Ceriani et al. (2019) estimated the total number of adult females nesting in Florida to be 51,319, based on nest count data from 2014-2018. The annual rate of nesting female increase from 1983-2019 for the Northern Recovery Unit (i.e., loggerheads nesting in Georgia, North Carolina, South

Carolina, and Virginia) is positive 1.3% (Bolten et al. 2019; NMFS and USFWS 2023). There is no significant trend in the annual number of nesting females in either the Peninsular Florida (1989-2018) or Northern Gulf of Mexico (1997-2018) units over the last several decades (NMFS and USFWS 2023). Overall, the latest 5-year status review concluded that the DPS as a whole demonstrates a stable (neither increasing nor decreasing) population trend (NMFS and USFWS 2023). DiMatteo et al. (2024) modeled survey data to estimate an in-water abundance of juvenile and adult loggerheads (> 40 cm) along the U.S. Atlantic Coast of 193,423 turtles.

Northwest Atlantic DPS loggerhead sea turtles are expected to experience mortality, non-auditory injury, AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic Coast and in the Gulf of America from AFTT sonar, air guns, and explosives. The quantitative acoustic effects analysis (i.e., NAEMO) predicts 28,007 instances of behavioral harassment, 48,437 instances of TTS, 416 instances of AINJ, nine instances of non-auditory injury, and up to three mortalities are reasonably certain to occur annually, in a maximum year of AFTT sonar, air guns and explosives activities.

As discussed in Section 6.2.1, a non-auditory injury can impact an individual sea turtle's fitness, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. Depending on the type of injury (e.g., severity, location) and other relevant factors (e.g., animal life stage, size, condition prior to exposure), a reduction in fitness from non-auditory injury could either be temporary with recoverable impacts, or result in long-term fitness consequences for some individuals. While long-term fitness consequences could affect population growth, the quantitative analysis estimated a relatively small number (i.e., up to eight per year) of non-auditory injuries to loggerhead sea turtles. Considering the size (i.e., over 50,000 nesting females in Florida alone) of this stable population, any such fitness impacts would not result in an appreciable reduction in the reproductive potential or growth rate of the Northwest Atlantic DPS of loggerhead sea turtles.

Auditory injury in the form of PTS could decrease an individual sea turtle's ability to detect danger such as approaching vessels or predators; and may reduce foraging or breeding opportunities or increase risks of sustaining other harm. While some proportion of loggerhead sea turtle PTS exposures could result in minor fitness consequences, sea turtles, in general, are not considered to rely extensively on their hearing for important life functions (Popper et al. 2014; Nelms et al. 2016). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions.

We have no information to suggest that TTS in sea turtles would result in fitness consequences to individuals or the populations to which they belong. Similarly, behavioral and physiological responses to acoustic stressors are expected to be temporary and episodic, with no reduction in fitness of individual turtles. Any adverse effects to sea turtles resulting from TTS or behavioral responses are expected to be relatively minor and short-term.

Based on our sea turtle vessel strike exposure analysis (Section 6.2.2), we estimate there would be 30 lethal vessel strikes of Northwest Atlantic DPS loggerhead sea turtles annually due to the

proposed action. The NAEMO analysis also estimated up to three mortalities from Navy explosives annually as a result of the proposed action. Since some of the turtles killed by vessel strike and explosives will likely be females, the action may result in a reduction in the reproductive potential of this species. Loss of a sexually mature female will have immediate effects on recruitment, while future lost reproductive potential from mortality of a juvenile female might not be realized for several years. From our exposure analysis (Section 6.2.2) we anticipate that approximately 53% of the loggerhead sea turtle vessel strikes will be females. The loss of 19 (i.e., 16 from vessel strike and three from explosives) female Northwest Atlantic DPS loggerhead sea turtles is likely to exert some effect on the population numbers in the near-term in the action area. However, the anticipated mortalities from vessel strike and explosives are not likely to impact the survival and recovery of this species, as this level of mortality represents a small fraction (0.04% annually) of the estimated adult female population. This is a highly conservative estimate of the proportional reproductive potential lost, since it assumes all females killed would be adult, and is based only on the estimated number of nesting females (51,319) in Florida (NMFS and USFWS 2015; Ceriani et al. 2019). We do not consider this to be an appreciable reduction in the numbers of female Northwest Atlantic DPS loggerhead sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of the Northwest Atlantic DPS loggerhead sea turtle, we do not expect this level of mortality to impact the survival or recovery of this population. In addition, the relatively small loss of reproductive potential resulting from vessel strike and explosives will not affect the current geographic range of this population, and no reduction in the distribution of this DPS is expected as a result of the proposed action.

The 2009 Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle identified the major actions needed to recover this DPS (NMFS and USFWS 2008). Relevant to the proposed action, these include minimize vessel strike mortality and ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing at a greater rate than strandings of similar age classes. Demographic recovery criteria include the following statistically significant minimum levels of increase in the annual number of loggerhead nests over 50 years for each recovery unit: 1) Northern Recovery Unit: 2% (minimum of 14,000 nests); 2) Peninsular Florida Recovery Unit: 1% (minimum of 106,100 nests); 3) Dry Tortugas Recovery Unit: 3% (minimum of 1,100 nests); and 4) Northern Gulf of Mexico Recovery Unit: 3% (minimum of 4,000 nests). While we do anticipate Northwest Atlantic DPS loggerhead sea turtle mortalities from vessel strike and explosives, and injuries (some with fitness consequences) from both vessel strike and acoustic stressors, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of this population of loggerhead sea turtles. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this DPS.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or

cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of Northwest Atlantic DPS loggerhead sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of Northwest Atlantic DPS loggerhead sea turtles in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of Northwest Atlantic DPS loggerhead sea turtles in the wild.

8.1.11 Leatherback Sea Turtle

Based on the best available data, the total index of nesting female abundance for the leatherback Northwest Atlantic population is 20,659 females (NMFS and USFWS 2020b). This population exhibits a decreasing nest trend that has become more pronounced in recent years (2008 to 2017), and the available nesting data reflect a steady decline for more than a decade (Group 2018; NMFS and USFWS 2020b). There are no leatherback nesting sites located within the AFTT action area. The best available estimate of leatherback sea turtle (> 40 cm) in-water abundance along the U.S. Atlantic Coast is 21,984 turtles (DiMatteo et al. 2024).

Leatherback sea turtles are expected to experience mortality, non-auditory injury, AINJ, TTS, behavioral and physiological stress responses throughout waters off the Atlantic Coast and in the Gulf of America from AFTT sonar, and explosives. The quantitative acoustic effects analysis (i.e., NAEMO) predicts 917 instances of behavioral harassment, 3,764 instances of TTS, 70 instances of AINJ, two instances of non-auditory injury, and up to one mortality are reasonably certain to occur annually, in a maximum year of AFTT sonar and explosives activities.

As discussed in Section 6.2.1, a non-auditory injury can impact an individual sea turtle's fitness, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. Depending on the type of injury (e.g., severity, location) and other relevant factors (e.g., animal life stage, size, condition prior to exposure), a reduction in fitness from non-auditory injury could either be temporary with recoverable impacts, or result in long-term fitness consequences for some individuals. While long-term fitness consequences could affect population growth, the quantitative analysis estimated a relatively small number (i.e., up to two per year) of non-auditory injuries to leatherback sea turtles. Considering the size of the population (i.e., over 20,000 nesting females alone), any such fitness impacts would not result in an appreciable reduction in the reproductive potential or growth rate of either the Northwest Atlantic or range wide population of leatherback sea turtles.

Auditory injury in the form of PTS could decrease an individual sea turtle's ability to detect danger such as approaching vessels or predators; and may reduce foraging or breeding opportunities or increase risks of sustaining other harm. While some proportion of leatherback sea turtle PTS exposures could result in minor fitness consequences, sea turtles, in general, are not considered to rely extensively on their hearing for important life functions (Popper et al.

2014; Nelms et al. 2016). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions.

We have no information to suggest that TTS in sea turtles would result in fitness consequences to individuals or the populations to which they belong. Similarly, behavioral and physiological responses to acoustic stressors are expected to be temporary and episodic, with no reduction in fitness of individual turtles. Any adverse effects to sea turtles resulting from TTS or behavioral responses are expected to be relatively minor and short-term.

Based on our sea turtle vessel strike exposure analysis (Section 6.2.2), we estimate there would be two lethal vessel strikes of leatherback sea turtles annually due to the proposed action. The NAEMO analysis also estimated up to one mortality from Navy explosives annually as a result of the proposed action. Since some of the leatherback turtles killed by vessel strike and explosives will likely be females, the action may result in a reduction in the reproductive potential of this species. Loss of a sexually mature female will have immediate effects on recruitment, while future lost reproductive potential from mortality of a juvenile female might not be realized for several years. However, the small number of mortalities anticipated is not likely to impact the survival and recovery of leatherback sea turtles. Even if we assume that all vessel strike and explosive mortalities would be of nesting females, the estimated mortality levels still represent an extremely small fraction (i.e., less than 0.01%) of the estimated 20,659 nesting females in the Northwest Atlantic leatherback population, and an even smaller percentage of the range wide species nesting female abundance. We do not consider this to be an appreciable reduction in the numbers of female leatherback sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of leatherback sea turtles, we do not expect this level of mortality to impact the survival or recovery of this species. In addition, the relatively small loss of reproductive potential resulting from vessel strikes and explosives will not affect the current geographic range of this species, and no reduction in the distribution of this species is expected as a result of the action.

NMFS and USFWS (1992) identified the major actions needed to recover the U.S. Atlantic population of leatherback sea turtles. Relevant to the proposed action, these include protecting and managing turtles and habitat in the marine environment. Criteria for delisting the U.S. Atlantic leatherback population include a 25-year increasing trends in the adult female nester population, based on nesting trend data from Puerto Rico, USVI, and the east coast of Florida. While we do anticipate a very small number of leatherback mortalities from vessel strike and explosives, and injuries (some with fitness consequences) from both vessel strike and acoustic stressors, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of leatherback sea turtles. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this species.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of leatherback sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of leatherback sea turtles in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of leatherback sea turtles in the wild.

8.1.12 Atlantic Salmon – Gulf of Maine DPS

The Gulf of Maine DPS of anadromous Atlantic salmon was initially listed by USFWS and NMFS as an endangered species on November 17, 2000 (65 FR 69459). The marine range of this DPS extends from the Gulf of Maine, throughout the Northwest Atlantic Ocean, to the coast of Greenland. This DPS of Atlantic salmon currently exhibits critically low spawner abundance, poor marine survival, and is confronted with a variety of additional threats. Of the eight locally adapted populations that remain in the Gulf of Maine DPS, seven are supported by conservation hatcheries that act to buffer extinction risk.

The Gulf of Maine DPS of Atlantic salmon only occurs in the Northeastern portion of the action area, specifically within the Northeast Range Complexes, the Naval Undersea Warfare Center Newport Testing Range and nearby rivers and estuaries including some inshore locations within the action area (e.g., Bath, Maine) (Navy 2024c). From our effects analysis we determined that Atlantic salmon are likely to be adversely affected by AFTT activities involving explosive detonations. These activities can result in both lethal and non-lethal effects on individual salmon, though precise quantification of mortality rates remains challenging. Within the blast radius, salmon may experience immediate death, severe injury, temporary threshold shifts (TTS) in hearing, or behavioral disruptions. Atlantic salmon may experience severe internal injuries, barotrauma, or disorientation when exposed to explosive shock waves. Lethal impacts occur when individuals are within close proximity to detonations, particularly in shallow or mid-depth water columns. Large explosions can cause organ rupture, hemorrhaging, and fatal trauma from sudden pressure changes. When exposed to underwater explosions, the fish may become temporarily disoriented, potentially increasing their vulnerability to predation and other environmental hazards (Peng et al. 2015).

Further away from the blast, some salmon who are not injured may also detect the blast and exhibit a response. Even if not fatal, exposure to high-intensity shock waves and pressure variations can cause significant physiological stress, temporary disorientation, and impaired swimming ability. However, behavioral and physiological disruptions or responses from exposure to AFTT explosive stressors will be short-term and temporary. Due to the episodic and

temporary nature of AFTT activities involving explosives, we do not expect the sublethal effects to be realized at a magnitude that would significantly reduce individual salmon fitness. These responses are expected to be short-term and infrequent based on the low probability of co-occurrence between AFTT activities involving in-water explosives with Atlantic salmon. In addition, most of these activities will occur beyond 3 NM from shore and not in the bays and estuaries where Atlantic salmon would be present in higher numbers during seasonal migration periods.

Due to the lack of available density or abundance information for Atlantic salmon in the portion of the action area where AFTT explosives would be used, we cannot quantify the total number of individual fish that would be exposed to stressors from explosives. As such, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take (i.e., in the form of the number of fish suffering mortality, injury, TTS, and behavioral disruption) or to monitor take-related impacts in terms of individuals of Atlantic salmon. Although we are unable to quantify the number of Atlantic salmon that will be injured or killed from explosives, we assume based on location, duration and timing of exposures, that an extremely small proportion of the adult Gulf of Maine DPS Atlantic salmon would be impacted and potentially killed or injured. Most of the explosive activities that overlap with Atlantic salmon in the action area involve small NEWs (i.e., E4, 2.5–5 lb.) with relatively small ranges to mortality effects (Navy 2024c). In addition, Atlantic salmon do not overlap spatially with ship shock trials, the activity involving the largest NEW, which further reduces the likelihood of more serious effects from exposure to explosives.

While we do anticipate a very small number of Atlantic salmon mortalities and injuries (some with fitness consequences) from explosives, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of this population. While lethal effects and serious injuries could reduce reproductive potential, the loss of a very small percentage of adults from AFTT activities is not expected to significantly impact future adult returns. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this DPS. Since AFTT activities do not affect spawning or freshwater rearing habitats, impacts on early life stages are not anticipated. Besides explosives, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect the Atlantic salmon.

The Gulf of Maine DPS has experienced significant population declines, with current trends indicating negative growth rates. Multiple anthropogenic factors have contributed to this decline, including historical overexploitation, water quality degradation, river damming, and coastal development. Despite ongoing conservation efforts, adult salmon returns to Gulf of Maine DPS rivers remain far below historical levels. While the species faces numerous challenges, including changing environmental conditions, habitat degradation, and historical overexploitation, AFTT activities are not expected to appreciably reduce the abundance, distribution, or reproduction of the Gulf of Maine DPS of Atlantic salmon.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of the Gulf of Maine DPS of Atlantic salmon in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of the Gulf of Maine DPS of Atlantic salmon in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of the Gulf of Maine DPS of Atlantic salmon in the wild.

8.1.13 Atlantic Sturgeon

The Atlantic sturgeon, listed as endangered under the ESA (77 FR 5880, February 6, 2012), is a long-lived, anadromous species that migrates between freshwater spawning rivers and marine foraging habitats along the U.S. East Coast. Five distinct population segments (DPSs) occur within the AFTT action area: Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic. The species continue to be at risk from human-induced threats such as degraded water quality, habitat impacts from dredging, bycatch in state and Federally managed fisheries, and vessel strikes. (USFWS and NMFS 2022)

Atlantic sturgeon primarily use coastal and estuarine waters as migration corridors between spawning and foraging grounds. Within the AFTT action area, they are at risk of exposure to explosive detonations and vessel strikes, with risk levels varying by DPS due to differences in habitat use and population distribution.

Explosive activities in offshore and nearshore training areas pose a potential risk to Atlantic sturgeon through exposure to underwater shock waves, barotrauma, and acoustic trauma. The likelihood of exposure varies by DPS, depending on the populations' migratory behavior, density and proximity to AFTT training and testing activities. Gulf of Maine, New York Bight, and Chesapeake Bay DPS Atlantic sturgeon are more likely to be exposed to explosive detonations from activities in nearshore coastal areas (i.e., Virginia Capes Range Complex Inshore under training activities, and in Mayport and Port Canaveral, Florida, and Naval Submarine Base New London testing activities) (Navy 2024c). The largest NEW detonations (bin E4, > 2.5–5 lb. NEW) in these areas have ranges to mortality and injury of 159 m and 440 m, respectively (Navy 2025b). Offshore, Atlantic sturgeon from all DPSs could be exposed to explosives in the VACAPES, Narragansett Bay, and JAX Range Complexes, where the largest explosive events involve net explosive weight (NEW) bins E10-E12, with potential injury zones extending 5,025 m (maximum 30,525 m) and mortality possible within 511 m (maximum 925 m) (Navy 2025b). However, these larger explosives are used infrequently and most explosives in offshore areas where Atlantic sturgeon occur have smaller NEWs (i.e., bin E5 or below). Areas such as the VACAPES and JAX Range Complexes may experience overlapping DPS exposure,

particularly for the New York Bight and Chesapeake Bay DPSs, where migratory pathways converge. The episodic nature of AFTT explosive activities reduces the likelihood of repeated exposure to any single individual.

As noted previously, information is not available to estimate the number of individual Atlantic sturgeon that are likely to be killed, injured, experience TTS, or behavioral disruption from explosives. However, based on best available information on Atlantic sturgeon habitat use and where most AFTT explosives are used, only a very small percentage of individuals from each of the Atlantic sturgeon DPSs are anticipated to be exposed to and affected by this stressor. The majority of AFTT in-water explosive activities do not occur in the inshore or nearshore (< 3 NM) areas where Atlantic sturgeon are likely to be present within the action area.

Much of this species' life history is spent outside of the action area either in freshwater habitats where explosives are not used or in nearshore locations where explosive activities are not common or where only small explosives with small ranges to mortality will be used (Navy 2024c). Since no Atlantic sturgeon spawning or freshwater rearing habitat will be affected by the AFTT proposed activities, impacts on spawning success and survival from egg to juvenile are not expected. Therefore, the only life stages NMFS anticipates will be present are adult and sub-adult Atlantic sturgeon.

Because AFTT explosive use is intermittent with effects that do not span a large area (e.g., most explosives used in the nearshore portions of the action area where sturgeon are most likely to occur have a range to mortality of < 160 m), we anticipate that most sturgeon in the action area would not co-occur with explosive stressors within a range to more severe adverse effects. Any TTS or behavioral disruptions resulting from explosives are considered temporary and not expected to linger to an extent that would affect an individual fish's fitness. Any temporary effects such as stress or behavioral disruptions are not expected to be persistent, and are anticipated to return to normal shortly after the exposure and not cause long-term consequences. Adult sturgeon not harmed or killed could continue to spawn in future years and produce juveniles to replace any individuals lost during AFTT explosive activities.

Based on the evidence available, including the environmental baseline and cumulative effects, and despite our inability to quantify the amount or extent of take from explosives exposures, we conclude that the loss of a small percentage of sub-adult or adult sturgeon from explosive stressors is not expected to appreciably decrease the number of returning adults in the future.

Vessel strikes represent a greater concern for Atlantic sturgeon due to their predictable use of nearshore migratory routes and estuarine habitats. The risk varies by DPS, depending on population size and the extent of overlap with Action Proponent vessel and USV operations. The Gulf of Maine DPS, estimated at fewer than 1,000 individuals, has limited overlap with high-intensity vessel traffic areas, making the risk of vessel strikes relatively low. From our Atlantic sturgeon vessel strike analyses (Section 6.3.2), the expected vessel strike mortality for this DPS is one individual annually, with a seven-year total of approximately three individuals. The New York Bight DPS, with an estimated adult and subadult population of about 35,000 individuals, experiences higher vessel traffic in the New York Harbor and Hudson River Estuary, where

collisions with Action Proponent vessels and USVs may contribute to cumulative mortality. The expected vessel strike mortality for this DPS is three individuals annually, with a seven-year total of approximately 19 individuals. The Chesapeake Bay DPS, estimated at about 9,000 adult and subadult individuals, is particularly vulnerable due to the high density of vessel traffic in the Norfolk and Chesapeake Bay region, where vessel strikes have been documented as a significant cause of mortality. The expected vessel strike mortality for this DPS is two individuals annually, with a seven-year total of approximately eight individuals. The Carolina DPS, with an estimated 1,300 adult and subadult individuals, is at moderate risk, particularly in the Charleston region where AFTT vessel operations occur. The expected vessel strike mortality for this DPS is one individual annually, with a seven-year total of approximately two individuals. The South Atlantic DPS, is estimated at nearly 15,000 adult and subadult individuals and has limited overlap with vessel activity, making the risk of strikes lower compared to northern DPSs. The expected vessel strike mortality for this DPS is two individuals annually, with a seven-year total of approximately 12 individuals.

Vessel strike mortality affects Atlantic sturgeon populations by reducing the number of spawning adults, which is particularly concerning given the species' slow maturation and low reproductive rates. The loss of even a few breeding females per year could contribute to localized declines and reduced genetic diversity within smaller DPSs. However, given the overall population sizes and expected rates of natural recruitment, the level of vessel strike mortality projected under AFTT activities is not expected to result in population-level declines. Besides explosives and vessel strike, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect Atlantic sturgeon. Thus, the abundance, distribution, and reproduction of Atlantic sturgeon are not expected to be appreciably reduced by AFTT activities.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce, the likelihood of survival of the Gulf of Maine, New York Bight, Chesapeake, Carolina, or South Atlantic DPSs of Atlantic sturgeon in the wild by reducing the reproduction, numbers, or distribution of these populations. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of Gulf of Maine, New York Bight, Chesapeake, Carolina, or South Atlantic DPSs of Atlantic sturgeon in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of Gulf of Maine, New York Bight, Chesapeake, Carolina, or South Atlantic DPSs of Atlantic sturgeon in the wild.

8.1.14 Giant Manta Ray

The giant manta ray, listed as threatened under the ESA (83 FR 2916, January 22, 2018), is a large, migratory elasmobranch that inhabits tropical, subtropical, and temperate waters globally. They frequent productive coastlines, oceanic islands, offshore pinnacles, and seamounts, often

aggregating in feeding and cleaning stations. Seasonal migrations correspond with zooplankton movement, water temperature changes, and mating behavior (Stewart et al. 2018a).

Giant manta rays could be present throughout the action area during AFTT activities. They are particularly vulnerable to stressors at or near the ocean surface due to their surface-oriented foraging behavior and tendency to aggregate in coastal and nearshore waters (Stewart et al. 2018a). Of the stressors resulting from the proposed action, we determined that giant manta rays are at the greatest risk from exposure to explosives, which will likely result in adverse effects to the species. They have the highest probability of exposure to explosives beyond 3 NM from shore within the VACAPES, JAX, and Navy Cherry Point Range Complexes due to the relatively higher amount of activities in these areas. In other areas such as the Gulf, Northeast, and Key West Range Complexes, the probability of exposure to explosives is lower.

Explosive activities conducted in military testing and training areas pose potential risks to giant manta rays, including mortality and serious injury. Manta rays may experience severe internal injuries, barotrauma, or disorientation when exposed to explosive shock waves. Lethal impacts occur when individuals are within close proximity to detonations, particularly in shallow or mid-depth water columns. Large explosions can cause organ rupture, hemorrhaging, and fatal trauma from sudden pressure changes. Giant manta rays have the potential to be exposed to ship shock trials, which involve the largest NEW (i.e., E16, > 7,250–14,500 lbs) used for AFTT. However, these activities are infrequent, with no more than five small ship shock trials every seven years of the proposed action. Due to the rarity of such activities and the species' relatively low presence in the action area, the likelihood of exposure to these events is low (Navy 2024c).

Even if not fatal, exposure to high-intensity shock waves and pressure variations can cause significant physiological stress, temporary disorientation, and impaired swimming ability. Sublethal injuries such as temporary threshold shifts (TTS) in hearing, minor barotrauma, and reduced foraging efficiency have been observed in similar large pelagic species (Wysocki et al. 2006; Popper et al. 2014; Casper et al. 2016). Studies on large elasmobranchs indicate that repeated exposure to high-intensity noise and pressure waves may result in chronic stress, immune suppression, and increased metabolic rates, potentially leading to long-term displacement from critical habitats and reduced reproductive success (Stewart et al. 2018a). However, behavioral and physiological disruptions or responses from exposure to AFTT explosive stressors will be short-term and temporary. Due to the episodic and temporary nature of AFTT activities involving explosives, we do not expect the sublethal effects to be realized at a magnitude that would significantly reduce individual fitness.

Due to the lack of available density or abundance information for giant manta rays in the portion of the action area where AFTT explosives would be used, we cannot quantify the total number of individual fish that would be exposed to stressors from explosives. As such, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take (i.e., in the form of the number of fish suffering mortality, injury, TTS, and behavioral disruption) or to monitor take-related impacts in terms of individuals of giant manta ray.

There is very little information on the abundance or spatial structure of the species within the action area. The population near St. Augustine, Florida is estimated at between 90 and less than 500 individuals (Kendall 2010). With small local populations (i.e., generally ranging from around 100 to 1,500 individuals), their life history traits and productivity estimates, particularly their low reproductive output and sensitivity to changes in adult survival rates, giant manta ray populations are inherently vulnerable to additional anthropogenic stressors (Miller 2017). Given their slow reproductive rates, stressors that result in mortality may have long-term effects on localized populations. Since females give birth only once every 2-3 years, even small annual losses may contribute to cumulative population declines over time (Stewart et al. 2018a). The death of mature, breeding females could have an immediate effect on the reproductive rate of the species, depending on the magnitude of impact compared to population levels. Sublethal effects on adult females may also reduce reproduction by hindering foraging success, as sufficient energy reserves are necessary for successful pup production (Stewart et al. 2018a).

While information is not available to estimate the exact number of giant manta rays likely to be affected, based on the best available information on species distribution and AFTT explosive use, only a small percentage of the total population within the AFTT action area is anticipated to be exposed at levels resulting in an adverse effect. Due to the relative rarity of this species in the vast majority of the action area, the dispersed nature of AFTT activities involving explosives, and the small range to effects resulting in mortality for most AFTT explosives, the lethal take of giant manta rays is expected to be relatively low. Most giant manta ray exposures to explosives are expected to result in short-term behavioral or physiological responses or TTS, with no long-term consequences to the individual's fitness or to the local population. While we do anticipate a very small number of giant manta ray mortalities and injuries (some with fitness consequences) from explosives, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of giant manta rays. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this species. Besides explosives, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect the giant manta ray. The abundance, distribution, and reproduction of giant manta rays are not expected to be appreciably reduced by AFTT activities.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of giant manta ray in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of giant manta rays in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of giant manta rays in the wild.

8.1.15 Oceanic Whitetip Shark

The oceanic whitetip shark, listed as threatened under the ESA (83 FR 4153, January 30, 2018), is a highly mobile pelagic apex predator historically found in tropical and subtropical waters worldwide. The species has experienced significant population declines due to overfishing and bycatch in commercial fisheries (Young et al. 2017). Oceanic whitetip sharks primarily occupy the open ocean but occasionally occur near the outer continental shelf and oceanic islands.

Within the AFTT action area, this species is considered relatively rare, with the highest probability of occurrence in the VACAPES, JAX, Navy Cherry Point, and Gulf Range Complexes. Explosive activities conducted in military testing and training areas pose potential risks to oceanic whitetip sharks, including mortality and serious injury. Mortality risk is highest within 400-1,000 m of large explosive events (bins E8-E12), and injury can occur at distances out to about 2,800 m (Navy 2025b). Oceanic whitetip sharks have the potential to be exposed to ship shock trials, which involve the largest NEW (i.e., E16, >7,250,000 lbs) used for AFTT. However, these activities are infrequent, with no more than five small ship shock trials every seven years of the proposed action. Due to the rarity of such activities and the species' relatively low presence in the action area, the likelihood of exposure to these events is low (Navy 2024c).

Even if not immediately fatal, large explosions can cause organ rupture, hemorrhaging, and fatal trauma from sudden pressure changes. Exposure to high-intensity shock waves and pressure changes can result in barotrauma, hearing impairment, and temporary displacement. These effects can increase metabolic stress, reduce foraging efficiency, and disrupt normal behavioral patterns (Casper et al. 2012; Popper et al. 2014). Unlike teleost fish, oceanic whitetip sharks lack a swim bladder, making them less susceptible to barotrauma but still vulnerable to sound and pressure wave exposure (Casper et al., 2012). Studies on large sharks indicate that repeated exposure to high-intensity noise and pressure waves may result in chronic stress, immune suppression, and increased metabolic rates, potentially leading to long-term displacement from critical habitats and reduced reproductive success (Young et al. 2017). However, behavioral and physiological disruptions or responses from exposure to AFTT explosive stressors will be short-term and temporary. Due to the rarity of such activities, the species' relatively low presence in the action area, and the limited number of exposures anticipated per individual, sub-lethal effects from explosives are not expected to appreciably impact individual fitness or affect long-term survival and recovery.

Due to the lack of detailed density or abundance information for oceanic whitetip sharks in the portion of the action area where AFTT explosives would be used, we cannot quantify the total number of individual sharks that would be exposed to stressors from explosives. As such, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take (i.e., in the form of the number of fish suffering mortality, injury, TTS, and behavioral disruption) or to monitor take-related impacts in terms of individual oceanic whitetip sharks.

In the Northwest Atlantic, throughout the action area, oceanic whitetip sharks are considered relatively rare. Thus, we anticipate impacts to oceanic whitetip sharks from AFTT activities to

not be common, particularly since this species does not possess a swim bladder making it less susceptible to injury or mortality from explosives than some other fish species. Moreover, due to spatial extent of the action area, and infrequent occurrence and short duration of explosives used throughout the AFTT action area where these sharks may occur, they are unlikely to be exposed multiple times within a short period of time. Thus, for these reasons, and although we cannot quantify how many oceanic whitetip sharks could be killed from explosives, we anticipate the number to be low. Any temporary effects such as stress or behavioral disruptions are not expected to result in long term consequences, and sharks are expected to return to normal shortly after the explosives exposure.

While information is not available to estimate the number of oceanic whitetip sharks likely to be affected, based on the best available information on species distribution and AFTT explosive use, only a small percentage of the total population within the AFTT action area is anticipated to be exposed at levels resulting in an adverse effect. Due to the relative rarity of this species in the vast majority of the action area, the dispersed nature of AFTT activities involving explosives, and the small range to effects resulting in mortality for most AFTT explosives, the lethal take of oceanic whitetip sharks is expected to be relatively low. Most oceanic whitetip shark exposures to explosives are expected to result in short-term behavioral or physiological responses or TTS, with no long-term consequences to the individual's fitness or to the local population. While we do anticipate a very small number of oceanic whitetip sharks mortalities and injuries (some with fitness consequences) from explosives, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of oceanic whitetip sharks. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this species.

For this reason, though instances of lethal, and non-lethal injury have the potential to reduce reproductive potential for oceanic whitetip sharks permanently, we do not expect explosive use to appreciably reduce the likelihood of survival of the species in the wild. Similar to other fish species (and turtles), the loss of a small percentage of adults is not expected to appreciably decrease the ability of successful reproduction in the future. Adults not harmed or killed would continue to reproduce in future years and produce juveniles to replace any individuals lost during AFTT activities. Besides explosives, based on our effects analysis, none of the other stressors, (identified in Section 2.4) resulting from the proposed action are likely to adversely affect the oceanic whitetip shark. Therefore, the abundance, distribution, and reproduction of oceanic whitetip sharks are not expected to be appreciably reduced by AFTT activities.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action, and Cumulative Effects, effects resulting from stressors caused by training and testing activities in the AFTT action area would not be expected to appreciably reduce the likelihood of survival of oceanic whitetip sharks in the wild by reducing the reproduction, numbers, or distribution of the species. Similarly, the effects of ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of oceanic whitetip sharks in the wild. Thus, we determine that the

proposed action would not appreciably reduce the likelihood of both survival and recovery of oceanic whitetip sharks in the wild.

8.1.16 Gulf Sturgeon

The Gulf sturgeon, listed as threatened under the ESA (56 FR 49653, November 5, 1991), is an anadromous species that migrates between freshwater spawning rivers and marine foraging habitats in the Gulf of America. Populations primarily occupy major river systems such as the Yellow, Choctawhatchee, and Apalachicola Rivers, using coastal estuarine waters during the non-spawning season. The species faces ongoing threats from habitat degradation, vessel strikes, and environmental contamination.

Gulf sturgeon are primarily at risk from explosive detonations and vessel strikes within the AFTT action area. Since juvenile and spawning life stages occur only in freshwater, only sub-adults and adults are expected to be affected. The highest probability of exposure to explosives is within the Panama City Division Testing Range, although mitigation measures such as avoiding line charge testing in this area between October and March will help reduce risk during peak migration periods. This will help avoid migration periods of Gulf sturgeon during that time as they transit to natal rivers of the Yellow, Choctawhatchee River, and Apalachicola River. This is expected to reduce the risk of exposure for individuals in that area.

Similar to other fish species considered in this opinion, the severity of adverse effects would be expected to increase the closer a sturgeon is located to the blast. The majority of the explosives used in coastal, nearshore areas where Gulf sturgeon typically occur are in bin E5 (> 5 to 10 lb. NEW) or below. Gulf sturgeon are not expected to be exposed to ship shock trials. Adverse effects depend on proximity to the detonation site, with the severity of effects increasing at closer distances. Any Gulf sturgeon located within about 150 m of a bin E5 explosive faces a high risk of mortality due to blast-induced trauma, internal hemorrhaging, and barotrauma (Navy 2025b). Sublethal injury risk for this NEW extends to nearly 370 m, while TTS could occur within 175 m of a single E5 explosive detonation. In addition, we expect physiological stress or behavioral responses to occur if individuals are located within any of these distances. Any TTS, behavioral or stress responses may have an energetic cost to the individual for the time it takes to recover, and therefore a reduced ability to detect threats in their environment, or carry out other important life functions during that time.

As noted previously, information is not available to estimate the number of individual Gulf sturgeon that are likely to be killed, injured, experience TTS, or behavioral disruption from explosives. However, based on best available information on the distribution of this species and where most AFTT explosives are used, instances of adverse effects are not expected to be common and only a very small percentage of the Gulf sturgeon population is anticipated to be exposed to and affected by this stressor. The vast majority of AFTT activities considered in this opinion do not occur within the range of Gulf sturgeon (i.e., most activity is concentrated along the Atlantic coast, as opposed to in the Gulf of America). Additionally, as noted above, AFTT activities will not occur in Gulf sturgeon freshwater spawning or rearing habitats, and the

proposed mitigation (Table 14, Section 2.3.2) at the Panama City Division Testing Range will further reduce the risk of adverse effects from explosives for this species.

Gulf sturgeon are susceptible to vessel strikes, particularly in coastal areas with frequent military vessel traffic. If a sturgeon is hit by a Navy or Coast Guard vessel we expect for it to sustain lethal or non-lethal injuries. Based on the information provided by the Action Proponents, published research and supplemental salvage data, we anticipate, on average, 0.21 Gulf sturgeon vessel or USV strikes annually, and up to two strikes every seven years, as a result of the proposed action.

Currently, seven rivers are known to support reproducing populations of Gulf Sturgeon. Since impacts of the proposed action are expected to occur in Gulf sturgeon winter feeding grounds in the Gulf of America, any of the seven populations could be affected by AFTT explosives and vessel strike. Gulf sturgeon population abundance estimates (USFWS and NMFS 2022) are 14,000 in the Suwannee River, 3,314 in the Choctawhatchee River, 911 in the Yellow River, and less than 500 in the other four rivers with known reproducing populations (NMFS 2009b; USFWS and NMFS 2022). In general, Gulf sturgeon populations in the eastern portion of their range within the Gulf of America appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty. Gulf sturgeon will continue to face the threats previously discussed into the reasonably foreseeable future such as habitat loss associated with dams and sills, habitat degradation associated with dredging, de-snagging, and contamination by pesticides, heavy metals, and other industrial contaminants. Effects of changing environmental conditions may also lead to accelerated changes in the habitats utilized by Gulf sturgeon. Thus, the long term population viability of Gulf sturgeon is currently uncertain.

Due to the relative rarity of this species in the vast majority of the action area, the dispersed nature of AFTT activities involving explosives, and the small range to effects resulting in mortality for most AFTT explosives, the lethal take of Gulf sturgeon is expected to be relatively low. Information is not available to partition the estimated impacts from AFTT on Gulf sturgeon into river subpopulations. Most Gulf sturgeon exposures to explosives are expected to result in short-term behavioral or physiological responses or TTS, with no long-term consequences to the individual's fitness or to the local population. While we do anticipate a very small number of Gulf sturgeon mortalities and injuries (some with fitness consequences) from explosives and vessel strike, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of Gulf sturgeon. AFTT activities have been occurring in the action area for decades, but effects from these activities have not been identified as a primary threat to this species (USFWS and NMFS 2022). Because Gulf sturgeon are a long-lived species, adults can reproduce more than once, and no juveniles or spawning habitats are likely to be affected by AFTT activities, we expect future reproduction and recruitment to replace any individuals lost from adverse effects during AFTT activities. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this species. Any temporary effects such as stress or behavioral disruptions are not expected to be persistent, and are anticipated to return to normal shortly after the exposure and not cause long-term consequences. Besides

explosives and vessel strike, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect the Gulf sturgeon. The abundance, distribution, and reproduction of Gulf sturgeon are not expected to be appreciably reduced by AFTT activities.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of Gulf sturgeon in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of Gulf sturgeon in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of Gulf sturgeon in the wild.

8.1.17 Scalloped Hammerhead Shark – Central and Southwest Atlantic DPS

The scalloped hammerhead shark, listed as threatened under the ESA (79 FR 38214, July 3, 2014), is a large, highly migratory elasmobranch species, typically occupying tropical and temperate coastal and offshore waters along the continental shelf and oceanic island slopes worldwide. Scalloped hammerhead sharks have experienced significant population declines due to commercial fishing, bycatch, and habitat degradation (Queiroz et al. 2019). The Central and Southwest Atlantic DPS is the only DPS that occurs in the action area, primarily in the southern KWRC and SFOMF. Juveniles inhabit nearshore nursery habitats for their first year before moving offshore (Duncan and Holland 2006).

However, since the range of the Central and Southwest Atlantic DPS of scalloped hammerhead shark overlaps only with a small portion of the action area, the likelihood of this species overlapping with AFTT activities is low. The vast majority of scalloped hammerheads sharks from this DPS would not likely be exposed to AFTT activities. Within the AFTT action area, the highest probability of exposure occurs in the KWRC and SFOMF, and portions of the JAX Range Complex.

Explosive activities conducted in military testing and training areas pose potential risks to scalloped hammerhead sharks, including mortality and serious injury. The species' surface-oriented schooling behavior increases vulnerability to surface and mid-water explosive events. Although there is a low probability of a scalloped hammerhead shark being exposed to explosives due to their distribution in the action area, if they are within close enough proximity to a blast, they could suffer mortality or injury. Mortality risk is highest within 400-600 m of large explosive events (bins E8-E12), and injury can occur at distances out to 1,350 m (Navy 2025b). Scalloped hammerhead sharks have the potential to be exposed to ship shock trials, which involve the largest NEW (i.e., E16, > 10,000 lbs) used for AFTT. However, these activities are infrequent, with no more than five small ship shock trials every seven years of the

proposed action. Due to the rarity of such activities and the species' relatively low presence in the action area, the likelihood of exposure to these events is low (Navy 2024c).

We cannot estimate the number of individual Central and Southwest Atlantic DPS scalloped hammerhead sharks that are likely to be killed, injured, or experience behavioral disruption from explosives due to lack of information on location and density of this species in the action area. However, based on the available information, a very small percentage of individuals from this DPS are anticipated to be exposed to explosives at levels that would result in an adverse effect. The action area is at the northern extent of this DPS' range, and the large majority of scalloped hammerheads from this DPS are not likely to occur in the action area during any portion of their life history. Due to the relative rarity of this species in the vast majority of the action area, the dispersed nature of AFTT activities involving explosives, and the small range to effects resulting in mortality for most AFTT explosives, the lethal take of scalloped hammerhead sharks is expected to be relatively low. While we do anticipate a very small number of scalloped hammerhead shark mortalities and injuries (some with fitness consequences) from explosives, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of scalloped hammerhead sharks. Thus, we do not expect this level of mortality and injury to impact the survival or recovery of this species.

Due to spatial extent of the action area, and infrequent occurrence and short duration of explosives used throughout the military ranges where these sharks may occur, individual sharks are unlikely to be exposed multiple times within a short period of time. Any behavioral or stress responses may have an energetic cost to the individual for the time it takes to recover, and therefore a reduced ability to detect threats in their environment, or carry out other important life functions during that time. However, these temporary effects are not expected to be persistent, and would return to normal shortly after the explosives exposure. We do not anticipate behavioral disruptions will have fitness consequences to affected individuals. Besides explosives, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect the Central and Southwest Atlantic DPS scalloped hammerhead shark. Therefore, the abundance, distribution, and reproduction of this DPS are not expected to be appreciably reduced by AFTT activities. While AFTT activities contribute additional stressors, they are not considered a primary driver of this DPS' decline.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of Central and Southwest Atlantic DPS scalloped hammerhead sharks in the wild by reducing the reproduction, numbers, or distribution of the species. Similarly, the effects of ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of Central and Southwest Atlantic DPS scalloped hammerhead sharks in the wild. Thus, we

determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of Central and Southwest Atlantic DPS scalloped hammerhead sharks in the wild.

8.1.18 Smalltooth Sawfish

The smalltooth sawfish, listed as endangered under the ESA (68 FR 15674, April 1, 2003), is a large, coastal elasmobranch historically found in the Gulf of America and along the southeastern U.S. coast. The species has suffered significant population declines due to habitat destruction, bycatch in fisheries, and environmental degradation. Smalltooth sawfish primarily inhabit shallow coastal and estuarine environments, with juveniles using mangrove-lined nurseries for protection, while adults migrate into deeper coastal waters.

Explosive activities conducted in military testing and training areas pose potential risks to smalltooth sawfish, including mortality and serious injury. Smalltooth sawfish may experience severe internal injuries, barotrauma, or disorientation when exposed to explosive shock waves. Lethal impacts occur when individuals are within close proximity to detonations, particularly in shallow or mid-depth water columns. Large explosions can cause organ rupture, hemorrhaging, and fatal trauma from sudden pressure changes.

Within the AFTT action area, smalltooth sawfish are most frequently encountered in nearshore habitats of South Florida, including the KWRC. Explosive activities in nearshore training areas pose a risk to smalltooth sawfish, particularly due to their demersal (bottom-dwelling) nature and reliance on coastal habitats. The majority of explosives used in sawfish-inhabited areas are in bins E4-E6, with occasional detonations of larger charge sizes (E10-E12). Smalltooth sawfish are not expected to overlap spatially with stressors from ship shock trials, which are only conducted within designated ship shock trial areas where sawfish are not known to occur.

Even if not fatal, exposure to high-intensity shock waves and pressure variations can cause significant physiological stress, temporary disorientation, and impaired swimming ability. Sublethal injuries such as TTS in hearing, minor barotrauma, and reduced foraging efficiency have been observed in other large fish species (Wysocki et al. 2006; Popper et al. 2014; Casper et al. 2016). However, behavioral and physiological disruptions or responses, and TTS from exposure to AFTT explosive stressors will be short-term and temporary. Due to the episodic and temporary nature of AFTT activities involving explosives, we do not expect the sublethal effects to be realized at a magnitude that would significantly reduce individual fitness.

Due to the lack of available density or abundance information for smalltooth sawfish in the portion of the action area where AFTT explosives would be used, we cannot quantify the total number of individual fish that would be exposed to stressors from explosives. As such, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take (i.e., in the form of the number of fish suffering mortality, injury, TTS, and behavioral disruption) or to monitor take-related impacts in terms of individuals of smalltooth sawfish.

There is very little information on the abundance or spatial structure of the species within the action area. Carlson and Simpfendorfer (2015) used encounter densities to estimate the female population size to be 600. Chapman et al. (2011) analyzed genetic data from tissue samples (fin clips) to estimate the effective genetic population size as 250 to 350 adults. Given their small population size, life history traits and productivity estimates, particularly their low reproductive output and sensitivity to changes in adult survival rates, smalltooth sawfish are inherently vulnerable to additional anthropogenic stressors. Given their slow reproductive rates, stressors that result in mortality may have long-term effects on localized populations. The death of mature, breeding females could have an immediate effect on the reproductive rate of the species, depending on the magnitude of impact compared to population levels.

While information is not available to estimate the exact number of smalltooth sawfish likely to be affected, based on the best available information on species distribution and AFTT explosive use, only a small percentage of the total population within the AFTT action area is anticipated to be exposed at levels resulting in an adverse effect. The number of smalltooth sawfish mortalities from AFTT explosive activities is expected to be extremely small due to the following: 1) the very small portion of the action area occupied by this species and relative rarity of this species in the vast majority of the action area, 2) the small number of AFTT activities involving in-water explosives in the nearshore areas occupied by this species, and 3) the small range to effects resulting in mortality for most AFTT in-water explosives that would be used in nearshore areas where sawfish may occur. Most smalltooth sawfish exposures to explosives are expected to result in short-term behavioral or physiological responses or TTS, with no long-term consequences to the individual's fitness or to the local population. While we do anticipate a very small number of smalltooth sawfish mortalities and injuries (some with fitness consequences) from explosives, the mortality and injury levels predicted will not result in an appreciable reduction in the numbers or reproductive rate of this species. Thus, we do not expect this level of mortality and injury to impact smalltooth sawfish survival or recovery. Besides explosives, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect smalltooth sawfish. The abundance, distribution, and reproduction of smalltooth sawfish are not expected to be appreciably reduced by AFTT activities.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of smalltooth sawfish in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of smalltooth sawfish in the wild.

Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of smalltooth sawfish U. S. Portion of Range DPS in the wild.

8.1.19 ESA-listed Coral Species

Corals are a diverse group of marine invertebrates that build reef structures through calcium carbonate deposition. ESA-listed coral species in the AFTT action area include boulder star coral, mountainous star coral, lobed star coral, pillar coral, rough cactus coral, elkhorn coral, and staghorn coral. These species inhabit shallow-water reef habitats, primarily in the Florida Reef Tract, Pulley Ridge, and mesophotic reefs of the Gulf of America. The ESA-listed corals considered in this opinion consist of many thousands, if not millions, of colonies that occur across a range of thousands of miles, including areas outside of U.S. jurisdiction (Table 75).

The locations where explosives activities in AFTT could overlap with ESA-listed corals are the KWRC, which has the highest likelihood of interaction with AFTT activities, the SFOMF which has minimal overlap with ESA-listed corals, and the Gulf Range Complex which contains mesophotic coral habitats but lower exposure risk due to the explosives activities being surface explosions or deep water detonations.

KWRC and SFOMF represent the primary areas where AFTT military activities are likely to intersect with coral habitats. Within these regions, approximately 17.9% of the substrate within coral depth ranges consists of hard bottom suitable for coral recruitment. However, even within these potentially suitable areas, actual coral presence is significantly lower. Reed et al. (2014) conducted surveys at both Pulley Ridge and the Dry Tortugas found coral cover of just 1.29% and 0.60% respectively, indicating that even in protected areas, coral abundance remains limited.

Table 75. Known Geographic Distribution and Abundance of ESA-listed Corals in the Action Area.

Species	Known distribution	Abundance estimate (number of colonies)
Elkhorn coral	Western Atlantic Ocean, Caribbean Sea, Gulf of America	Hundreds of thousands*
Staghorn coral	Western Atlantic Ocean, Caribbean Sea, southwestern Gulf of America	Tens of millions*
Pillar coral	Western Atlantic Ocean, Caribbean Sea	Tens of thousands*
Rough cactus coral	Western Atlantic Ocean, Caribbean Sea	Hundreds of thousands*
Lobed star coral	Western Atlantic Ocean, Caribbean Sea, Gulf of America	Tens of millions*
Mountainous star coral	Western Atlantic Ocean, Caribbean Sea, Gulf of America	Tens of millions*
Boulder star coral	Western Atlantic Ocean, Caribbean Sea, Gulf of America	Tens of millions*

*Minimum abundance information comes from the Final Rule to list 20 species of coral under the Endangered Species Act (79 FR 53851). For these species, the Rule lists an abundance estimate for a subset of areas within the range of the species. The Rule then states that the absolute abundance is higher than this estimate given the presence of the species in many other areas throughout its range.

Based on habitat surveys showing an average living hard coral coverage of 1.5%, the actual coral-occupied area within the impact zone is approximately 7.89 m² (526.1 m² × 0.015). This baseline metric provides the foundation for calculating potential mortality through various impact pathways. The assessment of coral mortality within the specified 0.13-acre (526.1 m²) impact zone requires careful analysis of multiple mortality pathways and their respective spatial distributions. By examining distinct impact mechanisms and applying established mortality thresholds, we can develop refined estimates of potential coral loss within this confined area. Within the 0.13-acre impact zone, coral coverage analysis indicates relatively sparse distribution of ESA-listed coral species. Within the action area habitat surveys indicate coral cover in training zones ranges from 5-20% of the total area impacted by explosives (Navy 2024j). The Action proponents approximate that training exercises in the Key West area impact less than one acre, roughly 4,047 m², each year. With coral cover estimates taken into account, the estimated coral habitat directly affected annually falls between 202 and 809 m². The previous Biological Opinion 2018 identified an estimate of .13 acres or approximately 526 m² which fall into the estimate and coincides with historical impact area calculations for the KWRC and SFOMF.

As discussed in more detail in our effects analysis (Section 6.4.2), we expect that ESA-listed corals will be affected by multiple stressors resulting from AFTT explosives including pressure wave effects, physical strike impacts from expended materials, and secondary impacts from sedimentation and interactions with secondary environmental stressors. The combination of direct physical impacts, pressure wave effects, and sediment stress creates conditions that may inhibit natural recovery processes, potentially extending mortality effects beyond initial impact periods. Physical impacts from military training activities create immediate mortality through several mechanisms. Within the 7.89 m² of live coral coverage we estimate approximately 3.16 m² of exposed coral area falls within primary impact zones experiencing immediate mortality through multiple pathways, and approximately 3.95 m² of exposed coral area falls within secondary impact zones experiencing delayed or partial mortality through sediment and secondary effects. From our effects analysis (Section 6.4.2), we estimate the total annual area of adult ESA-listed coral mortality from AFTT explosive operations at 4.56 m² in the shallow water explosive zone identified in the proposed action. Since AFTT explosive activities affecting coral are typically conducted in the same (or very similar) locations year after year, the total 7-year estimated area of ESA-listed coral mortality will not exceed 7.89 m². We do not have available information to estimate the proportion of the impacted area occupied by each of the seven ESA-listed coral species that will be affected by AFTT explosives. Although we anticipate that some ESA-listed coral larvae will be impacted by AFTT explosive activities, we do not have sufficient information on the distribution or abundance of coral larvae or the spatial overlap with AFTT explosive stressors to quantify this impact.

To protect seafloor resources, the Action Proponents will maintain a 350 yd buffer zone around mapped shallow-water coral reefs (Section 2.3.2, Table 9). This mitigation measure will help prevent direct impacts from explosive activities on these sensitive habitats. Additionally, most detonations occurring near the bottom in key training areas like the KWRC utilize relatively small charges (2.5 lbs or less), further reducing potential damage to ESA-listed coral. While we do anticipate that some adult ESA-listed coral colonies will be impacted by AFTT explosives, the estimated impact area and associated mortality levels represent an extremely small fraction of the range-wide abundance estimates (Table 75) for each of the seven species that will be impacted. Similarly, while we anticipate impacts to ESA-listed coral larvae, the area within which coral larvae could be exposed to AFTT explosive stressors is extremely small relative to the vast range of coral larvae from these species throughout portions of the Western Atlantic Ocean, Caribbean Sea, and Gulf of America. This level of adult and larvae mortality will not result in an appreciable reduction in the numbers or reproductive rate of any of the ESA-listed coral species in the action area. Thus, we do not expect this level of mortality to impact ESA-listed coral survival or recovery. Besides explosives, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect ESA-listed coral species. The abundance, distribution, and reproduction of ESA-listed coral are not expected to be appreciably reduced by AFTT activities.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of ESA-listed coral species in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of ESA-listed coral species in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of the following ESA-listed coral species in the wild: elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star.

8.1.20 Queen Conch

The queen conch, a large marine gastropod, is widely distributed throughout the Caribbean, Florida, and the Gulf of America. Due to its ecological and economic importance, the species has experienced significant population declines from overfishing, habitat degradation, and changing environmental conditions effects. Queen conch populations are particularly vulnerable due to their slow growth rates, late sexual maturity, and reliance on seagrass habitats for spawning and juvenile development.

Queen conch populations within the AFTT action area are primarily found in the Florida Keys, South Florida, and parts of the Gulf of America. The AFTT BA (Navy 2024c) indicates that the seafloor impact area of explosions at Demolition Key is approximately 6,475 m² annually (1.6 acres), based on assessments from the (Navy 2024g) Marine Habitat Database Technical Report. The queen conch density estimate of 15.07 to 17.29 adults per acre in affected areas comes directly from the Marine Habitat Database Technical Report (Navy 2024g). These figures are based on surveys conducted in the KWRC and South Florida habitats by HDR Environmental Operations and Construction Inc. in 2013. This estimated density of queen conch in affected areas (i.e., from 15.07 to 17.29 adults per acre) translates to roughly 3.72 to 4.27 conch per 100 m². Based on this density, from our effects analysis (Section 6.4.2) we estimate that the number of queen conch exposed within the explosives impact zone is between 241 to 277 individuals annually. Given these density estimates and the overlap with explosive activities conducted as part of AFTT may impact queen conch populations through direct mortality, injury from barotrauma, substrate destabilization, and displacement from critical seagrass habitats. The magnitude of these effects depends on the proximity of individuals to detonation sites and the intensity of the shock wave propagation through benthic habitats. Of those exposed, the estimated annual queen conch mortality from AFTT explosive training activities is 24 to 28 individuals.

The cumulative impacts of explosions and environmental stressors on queen conch populations within the AFTT action area must be considered in the context of broader population declines

observed throughout the species' range. Queen conch reproduction is particularly sensitive to population density changes, as these organisms require direct contact for mating. Many jurisdictions report adult densities below the critical threshold of 50 adults per hectare, which is required for successful reproduction. Given these constraints, additional mortality from military activities, even at low levels, may contribute to mate-finding difficulties, lower reproductive output, and potential recruitment failure.

To protect marine resources, the Action Proponents maintain a 350-yard buffer zone around mapped shallow-water coral reefs and seagrass beds to prevent direct impacts from explosive activities on these sensitive habitats. Additionally, most detonations occurring near the bottom in key training areas like the KWRC utilize relatively small charges (2.5 lbs or less), further reducing potential damage to marine invertebrates. Another key mitigation measure involves surveying for queen conch at Demolition Key within 24 hours of an explosive event, and relocating any queen conch found within a 50-yd radius from the detonation location (Table 25).

While we do anticipate that some queen conch will be killed or seriously injured by AFTT explosives, the estimated mortality levels represent an extremely small fraction of the range-wide population abundance estimate which ranges from 451 million to 1.49 billion individuals (Horn et al. 2022). This level of mortality will not result in an appreciable reduction in the numbers or reproductive rate of queen conch in the action area. Thus, we do not expect this level of mortality to impact queen conch survival or recovery. Besides explosives, based on our effects analysis, none of the other stressors resulting from the proposed action are likely to adversely affect queen conch. The abundance, distribution, and reproduction of queen conch are not expected to be appreciably reduced by AFTT activities. While localized impacts from explosions may cause temporary or small-scale population effects, these are not expected to result in significant declines across the broader population. Furthermore, mitigation measures such as avoiding explosive activities near critical seagrass habitats and monitoring habitat conditions will help minimize impacts.

In summary, based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Action Proponent will conduct in the AFTT action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of queen conch in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing AFTT activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of queen conch in the wild. Thus, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of queen conch.

9 CONCLUSION

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the consequences of the proposed action and associated activities, and the cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of the following ESA-listed species in the wild: North Atlantic right whale, blue whale, fin whale, sei whale, Rice's whale, sperm whale, green turtle – North Atlantic DPS, hawksbill turtle, Kemp's ridley turtle, leatherback turtle, loggerhead turtle – Northwest Atlantic DPS, Atlantic salmon – Gulf of Maine DPS, Atlantic sturgeon – Gulf of Maine DPS, Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Gulf sturgeon, giant manta ray, oceanic whitetip shark, scalloped hammerhead shark – Central and Southwest Atlantic DPS, smalltooth sawfish, elkhorn coral, staghorn coral, pillar coral, rough cactus coral, lobed star coral, mountainous star coral, boulder star coral, and queen conch.

In Section 4.1.2, we determined the effects of exposure were discountable or a response would be insignificant and, therefore, the effects of the proposed action may affect, but are not likely to adversely affect the following ESA-listed species: Nassau grouper, and shortnose sturgeon. In Section 4.1.3, we determined the effects of the proposed action may affect, but are not likely to adversely affect designated or proposed critical habitat of the following species: North Atlantic right whale, Rice's whale, loggerhead turtle – Northwest Atlantic DPS, green turtle – North Atlantic DPS, Atlantic sturgeon – Gulf of Maine DPS, Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Nassau grouper, Gulf sturgeon, elkhorn coral, staghorn coral, pillar coral, rough cactus coral, lobed star coral, mountainous star coral, and boulder star coral.

10 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation as an act which actually kills or injures fish or wildlife, and may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR §222.102). NMFS defines the term "harass" in Policy Directive 02-110-19 as to create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR §402.02). Section 7(b)(4) and section 7(o)(2) of the ESA, as well as in regulation at 50 CFR §402.14(i)(5) provide that taking that is incidental to an otherwise lawful agency action is not

considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

When an action is reasonably certain to result in incidental take of ESA-listed marine mammals, section 7(b)(4) of the ESA requires that such taking be authorized under section 101(a)(5) of the MMPA in order for the Secretary to issue an ITS for ESA-listed marine mammals and that the ITS specify the measures identified as necessary to comply with section 101(a)(5) of the MMPA. As part of the proposed action, the Permits Division proposes to issue LOAs. Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA become effective only upon the issuance of the 101(a)(5) authorization. The marine mammal portion of this ITS is a preliminary statement. It will become final and effective upon the issuance of the authorization under section 101(a)(5) of the Marine Mammal Protection Act and NMFS's written confirmation to the Federal agency, for the duration of the authorization and with relevant revisions per the final authorization.

10.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent of such incidental taking on the species (50 CFR §402.14(i)(1)(i)). In the opinion, we determined that incidental take of ESA-listed species is reasonably certain to occur as a result of the proposed action. The amount or extent of take that will occur as a result of the proposed action was estimated based on the best information available. In some instances, as noted below, we used a surrogate for the amount or extent of take anticipated. When it is not possible or practicable to specify the amount or extent of take, a surrogate may be used if we: 1) describe the causal link between the surrogate and take of the listed species, 2) explain why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and 3) set a clear standard for determining when the level of anticipated take has been exceeded (50 CFR §402.14(g)(7)).

10.1.1 Marine Mammals and Sea Turtles

We summarize the anticipated amount of incidental take of ESA-listed marine mammals and sea turtles (by species or DPS) in Table 76 and Table 77. As discussed in Section 6.2.1, based on the available sea turtle density information, it is not possible, nor would it be an accurate representation of potential effects, to quantify take (i.e., in the form of the number of turtles suffering mortality, injury, TTS, and behavioral disruption) or to monitor impacts in terms of individual hawksbills (all sizes) or other ESA-listed sea turtles less than 40 cm, affected by acoustic stressors resulting from the proposed action. Because it is not practical to express the amount of anticipated take of hawksbills or smaller sea turtles from other species, we instead use

Table 76. Number and Type of ESA Takes of Marine Mammals and Sea Turtles Anticipated to Occur Over a Maximum Year of Activities from Acoustic and Explosive Stressors, and Over Every Seven Years from Vessel Strike, as a Result of AFTT Military Readiness Activities.

ESA-Listed Species	Acoustic and Explosive Stressors: Annual Take During Maximum Year of Activities				Vessel Strike: Take Every 7-year Period
	Harassment: TTS ^a / Significant Behavioral Response	Harm: Auditory Injury (PTS)	Harm: Non- Auditory Injury	Mortality	Mortality ^b
Marin Mammals					Navy / Coast Guard
North Atlantic Right Whale	305 / 109	2	0	0	0 / 0
Rice's Whale	215 / 88	3	0	0	0 / 0
Blue Whale	59 / 12	1	0	0	0 / 0
Fin Whale	1,927 / 689	21	0	0	1 / 1
Sei Whale	622 / 125	7	0	0	1 / 1
Sperm Whale	3,739 / 9,126	6	1	0	1 / 1
Sea Turtles					Navy and Coast Guard Combined Take
Green ^c – North Atlantic DPS	8,251 / 3,962	68	3	1	266
Hawksbill	^d	^d	^d	^d	1
Kemp's Ridley ^c	9,227 / 7,140	62	2	0	52
Leatherback ^c	3,764 / 917	70	2	1	13
Loggerhead ^c – Northwest Atlantic DPS	48,437 / 28,007	416	9	3	207

^a Depending on the TTS severity, there could potentially be injury (i.e., tissue damage) to marine mammals. If this is the case, for those instances of TTS resulting in injury ESA “take” would be reclassified as “harm” instead of “harassment.” However, at this time, we do not have sufficient information to determine whether (or at what level) TTS with injury is occurring as a result of the action.

^b No more than two total Navy vessel or USV strikes from the three species (fin, sei, and sperm) combined are exempted over each 7-year period of the proposed action. No more than two total Coast Guard vessel strikes from the three species (fin, sei, and sperm) combined are exempted over each 7-year period of the proposed action.

^c As discussed above, a surrogate was used for take of sea turtles less than 40 cm from acoustic/explosive stressors.

^d A surrogate was used for take of hawksbill sea turtles (all sizes) from acoustic and explosive stressors (see discussion above).

a surrogate measure to express the amount or extent of incidental take. The surrogate for the incidental take of hawksbill sea turtles (all sizes) and green (North Atlantic DPS), Kemp's ridley, loggerhead (North Atlantic DPS), and leatherback sea turtles less than 40 cm diameter is based on: 1) the ranges to effects, which are the distances in the water column that correlate with each of the predicted effects (e.g., significant behavioral response, TTS, AINJ, non-auditory injury, and mortality) from sonar and explosives in those areas occupied by hawksbills (all sizes) or other sea turtles (less than 40 cm diameter), and 2) sonar and explosive activity levels, which is the total number of hours or count (by sonar or explosive bin type) that would be used in the action area as part of the proposed action.

Predicted ranges to effects for ESA-listed sea turtles are calculated using NAEMO based upon sound exposure criteria, which are used to predict the onset of sea turtle mortality, injury (auditory and non-auditory), or TTS. For details on ranges to sea turtle effects from AFTT sonar and explosives see the AFTT Final Supplemental EIS/OEIS: *Appendix E. Acoustic and Explosive Impacts Analysis for Marine Mammals, Reptiles, and Fishes in the Atlantic Fleet Training and Testing Study Area* (Section 3.5, pp. 3-225 through 3-232) (Navy 2025b). Sea turtles within these ranges could be exposed above the effect threshold levels, and a portion may experience those effects.

Ranges to effects, in combination with sonar and explosive activity levels (i.e., the number of explosives used or sonar hours, by bin/sonar type, in portions of the action area), can be used to estimate the area within the water column within which hawksbill sea turtles (all sizes) and other ESA-listed sea turtles less than 40 cm would be exposed to a sound source at levels resulting in the anticipated effects (i.e., mortality, injury, AINJ, TTS). Thus, there is a causal link between the surrogate factors above (i.e., range to effects and activity level) and take of hawksbill sea turtles (all sizes), and green (North Atlantic DPS), Kemp's ridley, loggerhead (North Atlantic DPS), and leatherback sea turtles less than 40 cm, as a result of the proposed action. NAEMO predicted ranges to effects could change based on new model inputs, including changes in environmental data, new findings on the responses of sea turtles to impulsive and non-impulsive sound sources, or updated sound exposure criteria levels based on new information. Any increase in the predicted ranges to effects on sea turtles from explosives used in the action area would result in a larger area within the water column within which sea turtles would be exposed, and therefore, exceedance of the surrogate used to measure take of these species. Exceedance of an activity level as a trigger for consultation reinitiation is discussed below for any activity associated with take of an ESA-listed species.

Table 77. Number and Type of ESA Takes of Marine Mammals and Sea Turtles Anticipated to Occur Over Every Seven Years from Acoustic and Explosive Stressors as a Result of AFTT Military Readiness Activities

ESA-Listed Species	Acoustic and Explosive Stressors			
	Take Every 7-Year Period			
	Harassment: TTS ^a / Significant Behavioral Response	Harm: Auditory Injury (PTS)	Harm: Non- Auditory Injury	Mortality
North Atlantic Right Whale	1,967 / 715	8	0	0
Rice's Whale	1,454 / 593	6	0	0
Blue Whale	391 / 73	2	0	0
Fin Whale	12,772 / 4,526	131	0	0
Sei Whale	4,159 / 822	44	0	0
Sperm Whale	25,625 / 60,703	20	1	0
Sea Turtles				
Green ^b – North Atlantic DPS	53,632 / 26,404	451	16	4
Hawksbill	^c	^c	^c	^c
Kemp's Ridley ^b	60,503 / 49,284	422	2	0
Leatherback ^b	19,915 / 6,085	257	4	1
Loggerhead ^b – Northwest Atlantic DPS	319,676 / 189,219	2,739	60	10

^a Depending on the severity of TTS, there could potentially be injury (i.e., tissue damage) to marine mammals. If this is the case, the type of ESA “take” for those instances of TTS resulting in injury would be reclassified as “harm” instead of “harassment.” However, at this time, we do not have sufficient information to determine whether (or at what level) TTS with injury is occurring as a result of the action.

^b A surrogate was used for take of sea turtles less than 40 cm from acoustic and explosive stressors (see discussion above).

^c A surrogate was used for take of hawksbill sea turtles (all sizes) from acoustic and explosive stressors (see discussion above).

10.1.2 Fish

Table 78 shows the number of lethal takes of ESA-listed sturgeon anticipated to occur from vessel or USV strike as a result of the proposed action. These take estimates are derived from our Atlantic and Gulf sturgeon vessel strike analyses in Section 6.3.2, which we then rounded up to

the nearest whole integer. Therefore, the 7-year take estimate will not always equal seven times the annual estimate.

Table 78. Number of Lethal Takes of ESA-listed Sturgeon, by Species or DPS, Anticipated to Occur from Vessel or USV Strike as a Result of AFTT Military Readiness Activities

Species / DPS		Annual Lethal Strikes	7-Year Lethal Strikes
Atlantic Sturgeon			
	New York Bight DPS	3	19
	Chesapeake Bay DPS	2	8
	South Atlantic DPS	2	12
	Carolina DPS	1	3
	Gulf of Maine DPS	1	2
Gulf Sturgeon		1	2

As described in Section 6.3.1, due to the lack of available density or abundance information for ESA-listed fish species in the portion of the action area where AFTT explosives would be used, we cannot quantify the total number of individual fish from each species that would be exposed to stressors from explosives. As such, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take (i.e., in the form of the number of fish suffering mortality, injury, TTS, and behavioral disruption) or to monitor take-related impacts in terms of individuals of the following ESA-listed fish species: Atlantic salmon – Gulf of Maine DPS, Atlantic sturgeon – Gulf of Maine DPS, Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Gulf sturgeon, giant manta ray, oceanic whitetip shark, scalloped hammerhead shark – Central and Southwest Atlantic DPS, and smalltooth sawfish.

Because it is not practical to express the amount of anticipated take of these fish species, we instead use a surrogate measure to express the amount or extent of incidental take. The surrogate for the incidental take of the ESA-listed fish listed above is based on: 1) the ranges to effects, which are the distances in the water column that correlate with each of the predicted effects (e.g., mortality, injury, TTS) from explosives in those areas occupied by adults of these species, and 2) explosive activity level, which is the total number of explosives (by bin type) that would be detonated in the action area as part of the proposed action (see Section 6.3.1, Table 71 for details on ranges to effects to ESA-listed fish).

Predicted ranges to effects for ESA-listed fish species are calculated using NAEMO based upon sound exposure criteria which are used to predict the onset of mortality, injury, or TTS within fishes within the AFTT action area. As discussed above for sea turtles, ranges to effects, in

combination with explosive activity levels (i.e., the number of explosives used, by bin type, in portions of the action area), can be used to estimate the area within the water column within which fish would be exposed to an impulsive sound source at levels resulting in the anticipated effects (i.e., mortality, injury, TTS). Thus, there is a causal link between the surrogate factors above (i.e., range to effects and activity level) and take of ESA-listed fish species as a result of the proposed action. The surrogate for take of ESA-listed fish would be exceeded if new information indicates larger ranges to effects than predicted for our effects analysis, or activity levels involving the use of explosives are greater than the maximum levels proposed by the Action Proponents.

10.1.3 Invertebrates

As described previously in Section 6.4.2, for the proposed action, it is not possible, nor would it be an accurate representation of likely effects, to express the amount of anticipated take of ESA-listed corals as numbers of colonies, or to monitor take-related impacts in terms of individual colonies of these species. Therefore, the incidental take of ESA-listed corals is expressed as a habitat area surrogate as prescribed by 50 CFR 402.14(i). Anticipated take of ESA-listed corals would be a maximum 4.56 m² in a given year, and 7.89 m² over every seven years of the proposed action, which may be occupied by live hard coral cover, a subset of which would be occupied by ESA-listed corals.

From our queen conch explosives exposure analysis in Section 6.4.2, we anticipate that 259 individual queen conch will be exposed to explosives, on average, each year. Of those exposed, we anticipate no greater than 26 mortalities, with the remaining 233 experiencing sub-lethal injuries on average each year.

Activity Levels as Indicators of Take Resulting from Acoustic Stressors

As discussed in this opinion, the estimated take of ESA-listed marine mammals, sea turtles, fish,²⁷ and invertebrates from acoustic stressors is based on the NAEMO modeling, which represents the best available means of numerically quantifying take. As the level of modeled sonar, explosive or air gun use increases, the level of take is likely to increase as well. For take from acoustic sources specified above, feasible monitoring techniques for detecting and calculating actual take at the scale of AFTT activities do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on the NAEMO methodology, and the link between sonar, explosive, and air gun use and the level of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this Incidental Take Statement (ITS) that requires the Action Proponents to report to NMFS any exceedance (or anticipated exceedance) of activity levels specified in the preceding opinion and in the final MMPA rule

²⁷ For estimating take of ESA-listed fish, hawksbill sea turtles (all sizes) and green (North Atlantic DPS), Kemp's ridley, loggerhead (North Atlantic DPS), and leatherback sea turtles less than 40 cm, NMFS only used the ranges to effects modeled by the Navy's NAEMO model.

before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level for any activity associated with take of an ESA-listed species will require the Action Proponents to reinitiate consultation.

10.2 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement such measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

“Reasonable and prudent measures” refer to those actions that NMFS and USFWS consider necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR §402.02). Reasonable and prudent measures, along with the terms and conditions that implement them, cannot alter the basic design, location, scope, duration, or timing of the action, may involve only minor changes, and may include measures implemented inside or outside of the action area that avoid, reduce, or offset the impact of incidental take (50 CFR 402.14(i)(2)).

We believe the following RPMs are necessary and appropriate:

1. The Navy, Coast Guard, and NMFS Permits Division shall minimize effects to ESA-listed species from the use of active sonar and other transducers, air guns, explosives, and vessels during training and testing activities.
2. The Navy, Coast Guard, and NMFS Permits Division shall monitor and report to NMFS’s Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed species from the use of sonar and other transducers, air guns, explosives, and vessels during training and testing activities. This includes adherence to the monitoring and reporting measures specified in the final MMPA rule and LOAs.
3. The Navy shall collect information on the location and density of ESA-listed corals and queen conch in nearshore, shallow water portions of the AFTT action area where activities involving in-water explosives may occur.

We have not identified any other measures that are available to implement at this time that meet the parameters of 402.14(i)(2) and that would avoid, reduce or offset the impact of incidental take.

10.3 Terms and Conditions

To be exempt from the prohibitions of section 9 and any 4(d) rule that extends the protections of section 9 to threatened species, the Navy, Coast Guard and NMFS Permits Division must comply with the terms and conditions described below. The Navy, Coast Guard, and NMFS Permits Division have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR §402.14(i)(3)). Any incidental take that is identified in this ITS and is in compliance with the terms and conditions identified in this section is not a prohibited taking under the ESA (16 U.S.C. § 1536(o)), and no other authorization or permit under the ESA is required (50 CFR §402.14(i)(5)).

The following terms and conditions implement reasonable and prudent measure #1:

- a) The NMFS Permits Division shall ensure that all mitigation measures as prescribed in the updated final MMPA rule and LOAs are implemented by the Action Proponents.
- b) The Action Proponents shall continue to request technical assistance and implement adaptive management efforts in collaboration with NMFS to help inform future consultations on training and testing in the action area. Adaptive management discussions may include reviewing the feasibility of potential new measures to increase mitigation effectiveness (e.g., thermal detection of protected species).
- c) The Action Proponents shall work collaboratively with the NMFS ESA Interagency Cooperation Division and the NMFS Permits and Conservation Division through the adaptive management process to: 1) analyze and discuss the application of new information from the Rice's whale near real-time detection platform, as it becomes available; 2) evaluate the practicability and conservation benefits of newly proposed mitigation measures and/or changes to existing measures based on information from the Rice's whale near real-time detection platform; and 3) implement any new mitigation measures or changes to existing measures that meet the Action Proponents' Practicability Criteria and Sufficiently Beneficial requirements.

The following terms and conditions implement reasonable and prudent measure #2:

- a) The Action Proponents shall monitor training and testing activities and submit reports annually to the NMFS Permits Division and the NMFS ESA Interagency Cooperation Division, including the location and total hours and counts of active sonar hours, air gun shots, and in-water explosives used, and an assessment of whether activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the seven year period of the MMPA rule and LOAs.
- b) The Action Proponents shall report to the NMFS ESA Interagency Cooperation Division all observed injury or mortality of any ESA-listed species resulting from the proposed training and testing activities within the action area. The Action Proponents shall report

when enough data are available to determine if the dead or seriously injured ESA-listed species may be attributable to AFTT activities, including but not limited to, the use of explosives and vessel strike.

- c) In the event that Navy or Coast Guard personnel (uniformed military, civilian, or contractors while conducting Navy or Coast Guard work) discover a live or dead stranded marine mammal or sea turtle within the action area or on Navy or Coast Guard property, they shall report the incident to NMFS immediately or as soon as operational security considerations allow.
- d) If NMFS personnel determine that the circumstances of any of the strandings reported in 2(d) suggest investigation of the associated Navy or Coast Guard activities is warranted (see stranding and notification document for example circumstances), and an investigation into the stranding is being pursued, NMFS personnel will submit a written request to the Navy or Coast Guard asking that they provide the status of all sound sources and explosive use in the 48 hours preceding and within 50 km (27 NM) of the discovery/notification of the stranding by NMFS, or estimated time of stranding. The Navy or Coast Guard will submit this information as soon as possible, but no later than 7 business days after the request.
- e) The Action Proponents' annual AFTT reports shall include a confirmation that foreign military use of sonar and explosives, combined with the Action Proponents' use of sonar and explosives, did not cause exceedance of the analyzed levels (within each NAEMO modeled sonar and explosive bin) used for estimating predicted impacts, which formed the basis of our acoustic impacts effects analysis that was used to determine authorized levels of take under the MMPA and exempted take in this ITS. Only foreign military use of sonar and explosives during activities that are planned by and under the substantial control and responsibility of the U.S. Navy (i.e., part of the proposed action) fall within this requirement (see Section 2.2.3 for details).

The following terms and condition implements reasonable and prudent measure #3:

- a) The Navy shall, no less than once every seven years, conduct surveys in shallow water (0-150 ft) portions of the Key West Range Complex and Key West Range Complex Inshore where in-water explosive (including underwater explosives and explosives deployed against surface targets) activities regularly occur. These surveys shall be structured to: 1) confirm presence/absence and abundance/density of queen conch; 2) confirm presence/absence and abundance/density of ESA-listed coral species; and 3) to assess impacts to these species due to military activities (military expended material, evidence of explosive effects such as breakage). If feasible, surveys may include investigation of general trends in coral reef species composition, percent coral coverage, and condition (disease, predators, extent of breakage, etc.). Survey area and location will be selected collaboratively between Navy and NMFS during the adaptive management process.

11 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of an action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 CFR §402.02). The following conservation recommendations should be considered by the Action Proponents to minimize or avoid effects to threatened and endangered species associated with this action:

1. The Action Proponents should continue developing autonomous marine mammal detection technologies to reduce the risk of vessel strike.
2. The Navy should continue to conduct behavioral response studies to obtain additional response data on received sound levels, distances, and durations of exposures that marine mammals are likely to receive incidental to actual training activities, in order to further refine and improve on the acoustic effects quantitative analysis.
3. As practicable, the Action Proponents should supplement the proposed visual monitoring mitigation measures with passive and active acoustic monitoring for activities that could cause marine mammal injury or mortality.
4. The Action Proponents should coordinate with state and Federal resource managers to identify research priorities and carry out actions that aid in the recovery and management of North Atlantic right whales and Rice's whales.
5. The Action Proponents should conduct additional aerial surveys in the Mid-Atlantic region to detect North Atlantic right whales.
6. The Action Proponents should assist NMFS and other federal agencies in the development and implementation of a near real-time Rice's whale detection platform to mitigate vessel strike risk and assist with mission planning.
7. The Action Proponents should research the abundance and distribution of ESA-listed fish species in the action area to incorporate into Navy density models for estimating impacts to fish from acoustic and explosive stressors.
8. The Navy should continue to investigate the use of thermal imaging systems as a potential large whale vessel strike mitigation measure and the compatibility of such systems with AFTT activities with manned and unmanned vessels.
9. The Action Proponents should explore the use of new protocols and/or communication tools to improve on the collection of post-strike information for species identification following a large whale strike in the AFTT action area.

In order for NMFS's Office of Protected Resources Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on,

or benefiting, ESA-listed species or their critical habitat, the Navy, Coast Guard and NMFS Permits Division should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action. Notice can be provided to nmfs.hq.esa.consultations@noaa.gov with the ECO number for this consultation (from the signature page) in the subject line.

12 REINITIATION NOTICE

This concludes formal consultation on the Action Proponents' proposed AFTT Phase IV activities and the Permits Division's promulgation of regulations and issuance of incidental take authorizations pursuant to the MMPA. Consistent with 50 CFR §402.16(a), reinitiation of consultation is required and shall be requested by the Federal agency, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and:

- (1) If the amount or extent of incidental taking specified in the ITS is exceeded;
- (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered;
- (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the opinion; or
- (4) If a new species is listed or critical habitat designated that may be affected by the identified action.

13 REFERENCES

- ABRT. 2005. Atlantic *Acropora* Status Review Document. Report to National Marine Fisheries Service, Southeast Regional Office.
- Aburto, A., D. J. Rountry, and J. L. Danzer. 1997. Behavioral responses of blue whales to active signals. Naval Command, Control and Ocean Surveillance Center, RDT&E Division, Technical Report 1746, San Diego, CA.
- Ackerman, R. A. 1997. The nest environment and the embryonic development of sea turtles. Pages 83-106 in P. L. Lutz, and J. A. Musick, editors. The biology of sea turtles. CRC Press, Boca Raton.
- Acosta, A., and A. Acevedo. 2006. Population structure and colony condition of *Dendrogyra cylindrus* (Anthozoa: Scleractinia) in Providencia Island, Columbian Caribbean. Pages 1605-1610 in Proceedings of the 10th International Coral Reef Symposium, Okinawa, Japan.
- Acropora Biological Review Team. 2005. Atlantic Acropora Status Review Document.
- Adams, D. H., and E. Amesbury. 1998. Occurrence of the manta ray, *Manta birostris*, in the Indian River Lagoon, Florida. Florida Scientist:7-9.
- Adams, D. H., and R. Paperno. 2007. Preliminary assessment of a nearshore nursery ground for the scalloped hammerhead off the Atlantic coast of Florida. American Fisheries Society Symposium 50:165-174.
- Adey, W. H. 1978. Coral reef morphogenesis: A multidimensional model. Science 202(4370):831-837.
- Agerton, M., S. Narra, B. Snyder, and G. B. Upton. 2023. Financial liabilities and environmental implications of unplugged wells for the Gulf of Mexico and coastal waters. Nature Energy 8(5):536-547.
- Aguirre, A. A., and coauthors. 2006. Hazards associated with the consumption of sea turtle meat and eggs: A review for health care workers and the general public. Ecohealth 3(3):141-153.
- Alava, J. J., and coauthors. 2006. Loggerhead sea turtle (*Caretta caretta*) egg yolk concentrations of persistent organic pollutants and lipid increase during the last stage of embryonic development. Science of the Total Environment 367(1):170-181.
- Aleksa, K. T., C. R. Sasso, R. W. Nero, and D. R. Evans. 2018. Movements of leatherback turtles (*Dermochelys coriacea*) in the Gulf of Mexico. Marine Biology 165(10):158.
- Allen, M. R., H. de Coninck, O. P. Dube, and D. J. Heogh-Guldberg Ove; Jacob, Kejun; Revi, Aromar; Rogelj, Joeri; Roy, Joyashree; Shindell, Drew; Solecki, William; Taylor, Michael; Tschakert, Petra; Waisman, Henri; Halim, Sharina Abdul; Antwi-Agyei, Philip; Aragón-Durand, Fernando; Babiker, Mustafa; Bertoldi, Paolo; Bindi, Marco; Brown, Sally; Buckeridge, Marcos; Camilloni, Ines; Cartwright, Anton; Cramer, Wolfgang; Dasgupta, Purnamita; Diedhiou, Arona; Djalante, Riyanti; Dong, Wenjie; Ebi, Kristie L.; Engelbrecht, Francois; Fifita, Solomone; Ford, James; Forster, Piers; Fuss, Sabine; Hayward, Bronwyn; Hourcade, Jean-Charles; Ginzburg, Veronika; Guiot, Joel; Handa, Collins; Hijioka, Yasuaki; Humphreys, Stephen; Kainuma, Mikiko; Kala, Jatin; Kanninen, Markku; Kheshgi, Haroon; Kobayashi, Shigeki; Kriegler, Elmar; Ley, Debora; Liverman, Diana; Mahowald, Natalie; Mechler, Reinhard; Mehrotra, Shagun; Mulugetta, Yacob; Mundaca, Luis; Newman, Peter; Okereke, Chukwumerije; Payne, Antony; Perez, Rosa; Pinho, Patricia Fernanda; Revokatova, Anastasia; Riahi, Keywan; Schultz, Seth; Séférian, Roland; Seneviratne, Sonia I.; Steg, Linda; Suarez Rodriguez, Avelino G.;

- Sugiyama, Taishi; Thomas, Adelle; Vilariño, Maria Virginia; Wairiu, Morgan; Warren, Rachel; Zhou, Guangsheng; Zickfeld, Kirsten. 2018. Technical Summary. In: *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)].
- Altenritter, M. N., G. B. Zydlewski, M. T. Kinnison, and G. S. Wippelhauser. 2017. Atlantic sturgeon use of the Penobscot River and marine movements within and beyond the Gulf of Maine. *Marine and Coastal Fisheries* 9(1):216-230.
- Altieri, A. H., and K. B. Gedan. 2015. Climate change and dead zones. *Global Change Biology* 21(4):1395-1406.
- Alvarez-Filip, L., N. Estrada-Saldivar, E. Perez-Cervantes, A. Molina-Hernandez, and F. J. Gonzalez-Barrios. 2019. A rapid spread of the stony coral tissue loss disease outbreak in the Mexican Caribbean. *PeerJ* 7:e8069.
- Amorim, A., C. Arfelli, and L. Fagundes. 1998. Pelagic elasmobranchs caught by longliners off southern Brazil during 1974–97: an overview. *Marine and Freshwater Research* 49(7):621-632.
- Andrady, A. L. 2011. Microplastics in the marine environment. *Marine Pollution Bulletin*, 62(8), 1596–1605. doi: 10.1016/j.marpolbul.2011.05.030.
- Andrzejczek, S., and coauthors. 2018. Temperature and the vertical movements of oceanic whitetip sharks, *Carcharhinus longimanus*. *Scientific Reports* 8(1):8351.
- Anttila, C. K., C. C. Daehler, N. E. Rank, and D. R. Strong. 1998. Greater male fitness of a rare invader (*Spartina alterniflora*, Poaceae) threatens a common native (*Spartina foliosa*) with hybridization. *American Journal of Botany* 85:1597-1601.
- Aplin, J. A. 1947. The effect of explosives on marine life. *California Fish and Game* 33:23–30.
- Archer, F. I., and coauthors. 2013. Mitogenomic phylogenetics of fin whales (*Balaenoptera physalus* spp.): genetic evidence for revision of subspecies. *PLoS One* 8(5):e63396.
- Arfsten, D., C. Wilson, and B. Spargo. 2002. Radio frequency chaff: The effects of its use in training on the environment. *Ecotoxicology and Environmental Safety* 53:11-Jan.
- Armstrong, A. O., and coauthors. 2016. Prey density threshold and tidal influence on reef manta ray foraging at an aggregation site on the Great Barrier Reef. *PLoS One* 11(5):e0153393.
- Aronson, R. B., and W. F. Precht. 2001. White-band disease and the changing face of Caribbean coral reefs. *Hydrobiologia* 460(1):25-38.
- ASMFC. 2017. Atlantic Sturgeon Benchmark Stock Assessment Atlantic State Marine Fisheries Commission Arlington VA
- ASSRT. 2007. Status review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Regional Office, Atlantic Sturgeon Status Review Team.
- Ataman, A., and coauthors. 2021. Evaluating prevalence of external injuries on nesting loggerhead sea turtles *Caretta caretta* in southeastern Florida, USA. *Endangered Species Research* 46:137-146.

- Atkinson, S., D. Crocker, D. Houser, and K. Mashburn. 2015. Stress physiology in marine mammals: How well do they fit the terrestrial model? *Journal of Comparative Physiology B Biochemical, Systemic and Environmental Physiology* 185(5):463-486.
- Attard, C. R. M., and coauthors. 2010. Genetic diversity and structure of blue whales (*Balaenoptera musculus*) in Australian feeding aggregations. *Conservation Genetics* 11(6):2437-2441.
- Au, W. W. L., and M. Green. 2000. Acoustic interaction of humpback whales and whale-watching boats. *Marine Environmental Research* 49(5):469-481.
- Avens, L., and coauthors. 2025. Regional differentiation in somatic growth and maturation attributes for loggerhead sea turtles (*Caretta caretta*) in the Northwest Atlantic. *Marine Biology* 172(9):1-18.
- Avens, L., and K. J. Lohmann. 2003. Use of multiple orientation cues by juvenile loggerhead sea turtles, *Caretta caretta*. *Journal of Experimental Biology* 206(23):4317-4325.
- Avens, L., and coauthors. 2021. Hawksbill sea turtle life-stage durations, somatic growth patterns, and age at maturation. *Endangered Species Research* 45:127-145.
- Avens, L., J. C. Taylor, L. R. Goshe, T. T. Jones, and M. Hastings. 2009. Use of skeletochronological analysis to estimate the age of leatherback sea turtles *Dermochelys coriacea* in the western North Atlantic. *Endangered Species Research* 8(3):165-177.
- Azzara, A. J., W. M. V. Zharen, and J. J. Newcomb. 2013. Mixed-methods analytic approach for determining potential impacts of vessel noise on sperm whale click behavior. *Journal of the Acoustical Society of America* 134(6):4566-4574.
- Backus, R. H., S. Springer, and E. L. Arnold Jr. 1956. A contribution to the natural history of the white-tip shark, *Pterolamiops longimanus* (Poey). *Deep Sea Research* 3(3):178-188.
- Baird, R. W., and coauthors. 2017. Final Report for Commander, U.S. Pacific Fleet. Odontocete studies on the Pacific Missile Range Facility in February 2016: satellite tagging, photo-identification, and passive acoustic monitoring. .
- Bak, R. P. M., and S. R. Criens. 1982. Experimental fusion in Atlantic Acropora (Scleractinia). *Marine Biology Letters* 3:67-72.
- Baker, C. S., L. M. Herman, B. G. Bays, and G. B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales. Pages 5 in *Fifth Biennial Conference on the Biology of Marine Mammals*, New England Aquarium, Boston, Massachusetts.
- Balazik, M. 2016. Documented ship strikes in the James River and lower Chesapeake Bay from 2007 to 2016 [Unpublished data]. Richmond, Virginia: Virginia Commonwealth University. .
- Balazik, M., and coauthors. 2020. Dredging activity and associated sound have negligible effects on adult Atlantic sturgeon migration to spawning habitat in a large coastal river. *PLoS One* 15(3):e0230029.
- Balazik, M., M. Barber, and G. Garman. 2017a. Vessel related threats to reproductively active Atlantic sturgeon in a large coastal river system. Final Report. NOAA-NMFS Award No. NA16NMF4720358. .
- Balazik, M., G. Garman, J. Van Eenennaam, J. Mohler, and L. Woods. 2012a. Empirical Evidence of Fall Spawning by Atlantic Sturgeon in the James River, Virginia. *Transactions of the American Fisheries Society*, 141(6), 1465-1471.
- Balazik, M., and coauthors. 2012b. The Potential for Vessel Interactions with Adult Atlantic Sturgeon in the James River, Virginia. *North American Journal of Fisheries Management*, 32(6), 1062-1069. .

- Balazik, M. T., D. J. Farrae, T. L. Darden, and G. C. Garman. 2017b. Genetic differentiation of spring-spawning and fall-spawning male Atlantic sturgeon in the James River, Virginia. *PLoS One* 12(7):e0179661.
- Balazik, M. T., and J. A. Musick. 2015. Dual annual spawning races in Atlantic Sturgeon. *PLoS One* 10(5):e0128234.
- Balazs, G. H. 1991. Research Plan for Marine Turtle Fibropapilloma: Results of a December 1990 Workshop. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service [Southwest Fisheries Science Center].
- Barber, M. R. 2017. Effects of Hydraulic Dredging and Vessel Operation on Atlantic Sturgeon Behavior in a Large Coastal River. Virginia Commonwealth University, Richmond, VA.
- Barbieri, E. 2009. Concentration of heavy metals in tissues of green turtles (*Chelonia mydas*) sampled in the Cananéia Estuary, Brazil. *Brazilian Journal of Oceanography* 57(3):243-248.
- Barco, S., and coauthors. 2016. Loggerhead turtles killed by vessel and fishery interaction in Virginia, USA, are healthy prior to death. *Marine Ecology Progress Series* 555:221-234.
- Barco, S. G., Lockhart, G.G., Rose, S.A., Mallette, S.D., Swingle, W.M., and Boettcher, R. 2015. Virginia/Maryland Sea Turtle Research & Conservation Initiative Final Report.
- Barco, S. G., S. A. Rose, G. G. Lockhart, and A. DiMatteo. 2018. Sea Turtle Tagging and Tracking in Chesapeake Bay and Coastal Waters of Virginia: 2017 Annual Progress Report.
- Barko, J. W., and R. M. Smart. 1981. Comparative influences of light and temperature on the growth and metabolism of selected submersed freshwater macrophytes. *Ecological Monographs* 51(2):219-236.
- Barlow, J. 2016. Cetacean abundance in the California: Current estimated from ship-based line-transect surveys in 1991-2014. Southwest Fisheries Science Center, National Marine Fisheries Service 8604 La Jolla Shores Drive, La Jolla, CA 92037.
- Bartol, S. M., and D. R. Ketten. 2006. Turtle and tuna hearing. Pages 98-103 in R. W. Y. B. Swimmer, editor. *Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries*, volume Technical Memorandum NMFS-PIFSC-7. U.S Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.
- Bartol, S. M., J. A. Musick, and M. Lenhardt. 1999. Evoked potentials of the loggerhead sea turtle (*Caretta caretta*). *Copeia* 1999(3):836-840.
- Baulch, S., and C. Perry. 2012. A sea of plastic: Evaluating the impacts of marine debris on cetaceans. IWC Scientific Committee, Panama City, Panama.
- Baulch, S., and C. Perry. 2014. Evaluating the impacts of marine debris on cetaceans. *Marine Pollution Bulletin* 80(1-2):210-221.
- Baum, E. 1997. Maine Atlantic Salmon: A National Treasure. Atlantic Salmon Unlimited, Hermon, ME.
- Baumgartner, M. F., and D. M. Fratantoni. 2008. Diel periodicity in both sei whale vocalization rates and the vertical migration of their copepod prey observed from ocean gliders. *Limnology and Oceanography* 53(5part2):2197-2209.
- Baums, I. B., and coauthors. 2013. Genotypic variation influences reproductive success and thermal stress tolerance in the reef building coral, *Acropora palmata*. *Coral Reefs*.

- Baums, I. B., C. R. Hughes, and M. E. Hellberg. 2005. Mendelian microsatellite loci for the Caribbean coral *Acropora palmata*. *Marine Ecology Progress Series* 288:115-127.
- Beauvais, S. L., S. B. Jones, S. K. Brewer, and E. E. Little. 2000. Physiological measures of neurotoxicity of diazinon and malathion to larval rainbow trout (*Oncorhynchus mykiss*) and their correlation with behavioral measures. *Environmental Toxicology and Chemistry* 19(7):1875-1880.
- Begall, S., E. P. Malkemper, J. Červený, P. Němec, and H. Burda. 2013. Magnetic alignment in mammals and other animals. *Mammalian Biology* 78:10-20.
- Bejder, L., A. Samuels, H. Whitehead, and N. Gales. 2006. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour* 72(5):1149-1158.
- Berchok, C. L., D. L. Bradley, and T. B. Gabrielson. 2006. St. Lawrence blue whale vocalizations revisited: Characterization of calls detected from 1998 to 2001. *Journal of the Acoustical Society of America* 120(4):2340-2354.
- Bergmann, M., L. Gutow, and M. Klages. 2015. *Marine anthropogenic litter*. Springer.
- Bernasconi, M., R. Patel, and L. Nøttestad. 2012. Behavioral observations of baleen whales in proximity of a modern fishing vessel. Pages 335-338 in *The Effects of Noise on Aquatic Life*. Springer.
- Best, P. B., J. Bannister, R. L. Brownell, and G. Donovan. 2001. Right whales: Worldwide status. *The Journal of Cetacean Research and Management (Special Issue)* 2.
- Bianchi, T. S., and coauthors. 2010. The science of hypoxia in the Northern Gulf of Mexico: A review. *Science of the Total Environment* 408(7):1471-1484.
- Bielmyer, G. K., and coauthors. 2010. Differential effects of copper on three species of scleractinian corals and their algal symbionts (*Symbiodinium* spp.). *Aquatic Toxicology* 97(2):125-133.
- Bigelow, H., and W. Schroeder. 1953. *Fishes of the western North Atlantic, Part 2—Sawfishes, Guitarfishes, Skates and Rays*. Mem. Sears Found 1:588pp.
- Billsson, K., L. Westerlund, M. Tysklind, and P. Olsson. 1998. Developmental disturbances caused by chlorinated biphenyls in zebrafish (*Brachydanio rerio*). *Marine Environmental Research* 46:461-464.
- Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. Pages 199–231 in *The biology of sea turtles*. CRC Press, Boca Raton, Florida.
- Bjorndal, K. A., and A. B. Bolten. 2010. Hawksbill sea turtles in seagrass pastures: success in a peripheral habitat. *Marine Biology* 157:135-145.
- Blackwell, S. B., and coauthors. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. *Marine Mammal Science* 29:E342–E365.
- Blackwell, S. B., and coauthors. 2015. Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. *PLoS One* 10(6):e0125720.
- Blair, H. B., N. D. Merchant, A. S. Friedlaender, D. N. Wiley, and S. E. Parks. 2016. Evidence for ship noise impacts on humpback whale foraging behaviour. *Biol Lett* 12(8).
- Blondin, H., and coauthors. 2025. Vessel strike encounter risk model informs mortality risk for endangered North Atlantic right whales along the United States east coast. *Scientific Reports* 15(1):736.
- Blumenthal, J. M., and coauthors. 2009. Ecology of hawksbill turtles, *Eretmochelys imbricata*, on a western Caribbean foraging ground. *Chelonian Conservation and Biology* 8(1):1-10.

- Bocast, C., R. M. Bruch, and R. P. Koenigs. 2014. Sound production of spawning lake sturgeon (*Acipenser fulvescens* Rafinesque, 1817) in the Lake Winnebago watershed, Wisconsin, USA. *Journal of Applied Ichthyology* 30:1186-1194.
- Boerger, C. M., G. L. Lattin, S. L. Moore, and C. J. Moore. 2010. Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. *Marine Pollution Bulletin* 60(12):2275–2278.
- Boisseau, O., and coauthors. 2024. Passive acoustic surveys demonstrate high densities of sperm whales off the mid-Atlantic coast of the USA in winter and spring. *Marine Environmental Research*:106674.
- Bolten, A. B., and coauthors. 2019. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*) Second Revision (2008) Assessment of Progress Toward Recovery December 2019.
- Boman, E. M., and coauthors. 2019. Diet and growth of juvenile queen conch *Lobatus gigas* (Gastropoda: Strombidae) in native, mixed and invasive seagrass habitats. *Marine Ecology Progress Series* 621:143-154.
- Bonfil, R., S. Clarke, and H. Nakano. 2008. The biology and ecology of the oceanic whitetip shark, *Carcharhinus longimanus*. Pages 128-139 in M. D. Camhi, E. K. Pikitch, and E. A. Babcock, editors. *Sharks of the open ocean: Biology, Fisheries and Conservation*. Blackwell Publishing Ltd, Oxford, United Kingdom.
- Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. *Environmental Biology of Fishes* 48(1-4):399-405.
- Bort, J., S. M. V. Parijs, P. T. Stevick, E. Summers, and S. Todd. 2015. North Atlantic right whale *Eubalaena glacialis* vocalization patterns in the central Gulf of Maine from October 2009 through October 2010. *Endangered Species Research* 26(3):271-280.
- Bousman, W. G., and R. M. Kufeld. 2005. UH-60A Airloads Catalog. National Aeronautics and Space Administration.
- Bowman, V., and coauthors. 2024. Injuries to Pacific mackerel (*Scomber japonicus*) from underwater explosions. *ICES Journal of Marine Science* 81(8):1685-1695.
- Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the US Hawaiian Islands Exclusive Economic Zone. *Fishery Bulletin* 115(2).
- Brainard, R. E., and coauthors. 2011. Status review report of 82 candidate coral species petitioned under the U.S. Endangered species Act. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.
- Brame, A. B., and coauthors. 2019. Biology, ecology, and status of the smalltooth sawfish *Pristis pectinata* in the USA. *Endangered Species Research* 39:9-23.
- Brandt, M. E., and coauthors. 2021. The Emergence and Initial Impact of Stony Coral Tissue Loss Disease (SCTLD) in the United States Virgin Islands. *Frontiers in Marine Science* 8.
- Branstetter, B. K., and J. J. Finneran. 2008. Comodulation masking release in bottlenose dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 124(1):625-633.
- Branstetter, S. 1987. Age, growth and reproductive biology of the silky shark, *Carcharhinus falciformis*, and the scalloped hammerhead, *Sphyrna lewini*, from the northwestern Gulf of Mexico. *Environmental Biology of Fishes* 19(3):161-173.

- Braun, C., G. Skomal, S. Thorrold, and M. Berumen. 2015. Movements of the reef manta ray (*Manta alfredi*) in the Red Sea using satellite and acoustic telemetry. *Marine Biology*, 162, 2351–2362. .
- Breece, M., A. Higgs, and D. Fox. 2021. Spawning intervals, timing, and riverine habitat use of adult Atlantic Sturgeon in the Hudson River. *Transactions of the American Fisheries Society* 150(4):528-537.
- Breece, M. W., D. A. Fox, D. E. Haulsee, I. I. Wirgin, and M. J. Oliver. 2018. Satellite driven distribution models of endangered Atlantic sturgeon occurrence in the mid-Atlantic Bight. *ICES Journal of Marine Science* 75(2):562-571.
- Briggs, C., S. M. Shjegstad, J. Silva, and M. Edwards. 2016. Distribution of chemical warfare agent, energetics, and metals in sediments at a deep-water discarded military munitions site. *Deep Sea Research Part II: Topical Studies in Oceanography*, 128, 63–69.
- Brown, J. J., and G. W. Murphy. 2010. Atlantic sturgeon vessel-strike mortalities in the Delaware Estuary. *Fisheries* 35(2):72-83.
- Browne, M. A., and coauthors. 2015. Linking effects of anthropogenic debris to ecological impacts. *Proceedings of the Royal Society B: Biological Sciences* 282(1807):20142929.
- Brownell Jr, R. L., S. D. Mallette, and D. Cholewiak. 2024. Stranded Medium-Sized Baleen Whales (Sei, Bryde's Rice's) in US Western North Atlantic Waters. International Whaling Commission.
- Bruckner, A. 2012. Factors contributing to the regional decline of *Montastraea annularis* (complex). D. Yellowlees, and T. P. Hughes, editors. Twelfth International Coral Reef Symposium. James Cook University, Cairns, Australia.
- Brumm, H., and H. Slabbekoorn. 2005. Acoustic communication in noise. *Advances in the Study of Behavior* 35:151-209.
- Brundage III, H. M. 2008. Final Report of Investigations of shortnose sturgeon early life stages in the Delaware River, Spring 2007 and 2008.
- Bruno, J. F., L. E. Petes, C. Drew Harvell, and A. Hettinger. 2003. Nutrient enrichment can increase the severity of coral diseases. *Ecology letters* 6(12):1056-1061.
- Bruno, J. F., and coauthors. 2007. Thermal stress and coral cover as drivers of coral disease outbreaks. *PLoS biology* 5(6):e124.
- Budd, A. F., H. Fukami, N. D. Smith, and N. Knowlton. 2012. Taxonomic classification of the reef coral family Mussidae (Cnidaria: Anthozoa: Scleractinia). *Zoological Journal of the Linnean Society* 166(3):465-529.
- Bunch, A. J., K. B. Carlson, F. J. Hoogakker, L. V. Plough, and H. K. Evans. 2021. Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus* Mitchill, 1815) early life stage consumption evidenced by high-throughput DNA sequencing. *Journal of Applied Ichthyology* 37(1):12-19.
- Burgess, K. B., and coauthors. 2016. Manta birostris, predator of the deep? Insight into the diet of the giant manta ray through stable isotope analysis. *Royal Society Open Science* 3(11):160717.
- Burkhardt, K., and coauthors. 2025. Horizontal and vertical movement ecology of the oceanic whitetip shark (*Carcharhinus Longimanus*) in French Polynesia. *Marine Biology* 172(2):1-17.
- Burman, S. G., R. B. Aronson, and R. van Woesik. 2012. Biotic homogenization of coral assemblages along the Florida reef tract. *Marine Ecology Progress Series* 467:89-96.

- Busch, J., and coauthors. 2016. Quantifying exceptionally large populations of *Acropora* spp. corals off Belize using sub-meter satellite imagery classification. *Bulletin of Marine Science* 92(2):265-283.
- Busch, L. 2018. Email from Laura Busch (U.S. Navy, U.S. Fleet Forces, Environmental Readiness Division) to Eric MacMillan (NOAA, NMFS, Office of Protected Resources) regarding sperm whale vessel strike by a Navy vessel in May 2005.
- Busch, L. 2025. Email attachment from Laura Busch (U.S. Navy, U.S. Fleet Forces, Environmental Readiness Division) to Ron Salz (NOAA, NMFS, Office of Protected Resources) regarding recommended language on foreign military activities for Phase IV military readiness consultations
- Bush, P. G., G. C. Ebanks, and E. D. Lane. 1996. Validation of the ageing technique for the Nassau grouper (*Epinephelus striatus*) in the Cayman Islands. *Biology, fisheries and culture of tropical groupers and snappers*:449.
- Byers, J. E. 2021. Marine parasites and disease in the era of global climate change. *Annual Review of Marine Science* 13(1):397-420.
- Byrd, B., and coauthors. 2014. Strandings illustrate marine mammal biodiversity and human impacts off the coast of North Carolina, USA. *Fish. Bull* 112(1):1-23.
- Byrnes, J. E., P. L. Reynolds, and J. J. Stachowicz. 2007. Invasions and extinctions reshape coastal marine food webs. *PLoS One* 2(3):e295.
- Caballero-Aragón, H., S. Perera-Valderrama, N. Rey-Villiers, J. González-Méndez, and M. Armenteros. 2020. Population status of *Acropora palmata* (Lamarck, 1816) in Cuban coral reefs. *Regional Studies in Marine Science* 34.
- Caballero Aragón, H., and coauthors. 2019. Ecological condition of coral reef assemblages in the Cuban Archipelago. *Marine Biology Research* 15(1):61-73.
- Cairns, S. D. 1982. Stony corals (Cnidaria: Hydrozoa, Scleractinia) of Carrie Bow Cay, Belize. Pages 271-302 in K. Rützler, and I. G. Macintyre, editors. *The Atlantic Barrier Reef Ecosystem at Carrie Bow Cay, Belize., I. Structure and Communities., volume 1.* Smithsonian Institution Press, Washington, DC, USA.
- Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Jessie Huggins. 2009. Photographic identification of humpback and blue whales off the U.S. West Coast: Results and updated abundance estimates from 2008 field season. Final Report for Contract AB133F08SE2786. Cascadia Research, Olympia, Washington.
- Callier, M. D., and coauthors. 2018. Attraction and repulsion of mobile wild organisms to finfish and shellfish aquaculture: a review. *Reviews in Aquaculture* 10.4:924-949.
- Camargo, S. M., and coauthors. 2016. Structure and Genetic Variability of the Oceanic Whitetip Shark, *Carcharhinus longimanus*, Determined Using Mitochondrial DNA. *PLoS One* 11(5):e0155623.
- Cameron, P., J. Berg, V. Dethlefsen, and H. Von Westernhagen. 1992. Developmental defects in pelagic embryos of several flatfish species in the southern North Sea. *Netherlands Journal of Sea Research* 29(1):239-256.
- Campbell, J. G., and L. R. Goodman. 2004. Acute sensitivity of juvenile shortnose sturgeon to low dissolved oxygen concentrations. *Transactions of the American Fisheries Society* 133(3):772-776.
- Capper, A., L. J. Flewelling, and K. Arthur. 2013. Dietary exposure to harmful algal bloom (HAB) toxins in the endangered manatee (*Trichechus manatus latirostris*) and green sea turtle (*Chelonia mydas*) in Florida, USA. *Harmful Algae* 28:1-9.

- Carder, D. A., and S. Ridgway. 1990. Auditory brainstem response in a neonatal sperm whale. *Journal of the Acoustic Society of America* 88(Supplement 1):S4.
- Carlson, J., and E. Scott-Denton. 2011. Estimated incidental take of smalltooth sawfish (*Pristis pectinata*) and an assessment of observer coverage required in the South Atlantic and Gulf of Mexico shrimp trawl fishery. Sustainable Fisheries Division, Panama City Laboratory Contribution 10.
- Carlson, J. K., and S. Gulak. 2012. Habitat use and movement patterns of oceanic whitetip, bigeye thresher and dusky sharks based on archival satellite tags. *Collect. Vol. Sci. Pap. ICCAT* 68(5):1922-1932.
- Carlson, J. K., and J. Osborne. 2012. Relative abundance of smalltooth sawfish (*Pristis pectinata*) based on the Everglades National Park Creel Survey. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center.
- Carlson, J. K., J. Osborne, and T. W. Schmidt. 2007. Monitoring the recovery of smalltooth sawfish, *Pristis pectinata*, using standardized relative indices of abundance. *Biological Conservation* 136(2):195-202.
- Carlson, J. K., and C. A. Simpfendorfer. 2015. Recovery potential of smalltooth sawfish, *Pristis pectinata*, in the United States determined using population viability models. *Aquatic Conservation: Marine and Freshwater Ecosystems* 25(2):187-200.
- Carpenter, R. C. 1986. Partitioning herbivory and its effects on coral reef algal communities. *Ecological Monographs* 56(4):345-363.
- Carr, A. 1987. Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. *Marine Pollution Bulletin* 18(6):352-356.
- Carr, S., F. Tatman, and F. Chapman. 1996. Observations on the natural history of the Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi* Vladykov 1955) in the Suwannee River, southeastern United States. *Ecology of Freshwater Fish* 5(4):169-174.
- Carretta, J. V., Oleson, E.M., Forney, K.A., Muto, M.M., Weller, D.W., Lang, A.R., Baker, J., Hanson, B., Orr, A.J., Barlow, J., Moore, J.E. 2022. U.S. Pacific Marine Mammal Stock Assessments: 2021. U.S. Department of Commerce, NOAA, NMFS.
- Carretta, J. V., Oleson, E.M., Forney, K.A., Muto, M.M., Weller, D.W., Lang, A.R., Baker, J., Hanson, B., Orr, A.J., Barlow, J., Moore, J.E., Brownell, R. L. Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA, NMFS.
- Casal, A., and J. Orós. 2009. Plasma biochemistry and haematology values in juvenile loggerhead sea turtles undergoing rehabilitation. *The Veterinary Record* 164(21):663.
- Casper, B. M., T. J. Carlson, M. B. Halvorsen, and A. N. Popper. 2016. Effects of impulsive pile-driving exposure on fishes. Pages 125-132 in *The effects of noise on aquatic life II*. Springer.
- Casper, B. M., M. B. Halvorsen, and A. N. Popper. 2012. Are sharks even bothered by a noisy environment? *Adv Exp Med Biol* 730:93-7.
- Casper, B. M., P. S. Lobel, and H. Y. Yan. 2003. The hearing sensitivity of the little skate, *Raja erinacea*: A comparison of two methods. *Environmental Biology of Fishes* 68(4):371-379.
- Casper, B. M., and D. A. Mann. 2009. Field hearing measurements of the Atlantic sharpnose shark *Rhizoprionodon terraenovae*. *J Fish Biol* 75(10):2768-76.

- Casper, B. M. M., D. A. 2006. Evoked potential audiograms of the nurse shark (*Ginglymostoma cirratum*) and the yellow stingray (*Urobatis jamaicensis*). *Environmental Biology of Fishes* 76:101-108.
- Cassoff, R. M., and coauthors. 2011. Lethal entanglement in baleen whales. *Diseases of Aquatic Organisms* 96(3):175-185.
- Castellote, M., C. W. Clark, and M. O. Lammers. 2012. Acoustic compensation to shipping and air gun noise by Mediterranean fin whales (*Balaenoptera physalus*). Pages 1 in A. N. P. A. Hawkings, editor. *The Effects of Noise on Aquatic Life*. Springer Science.
- Caswell, H., M. Fujiwara, and S. Brault. 1999. Declining survival probability threatens the North Atlantic right whale. *Proceedings of the National Academy of Sciences* 96(6):3308-3313.
- Cerchio, S., S. Strindberg, T. Collins, C. Bennett, and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. *PLoS One* 9(3):e86464.
- Ceriani, S., P. Casale, M. Brost, E. Leone, and B. Witherington. 2019. Conservation implications of sea turtle nesting trends: elusive recovery of a globally important loggerhead population. *Ecosphere* 10(11):e02936.
- Ceriani, S. A., and A. B. Meylan. 2017. *Caretta caretta* (North West Atlantic subpopulation) (amended version of 2015 assessment). The IUCN Red List of Threatened Species 2017: e.T84131194A119339029.
- CETAP. 1982. A characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U.S. outer continental shelf. Cetacean and Turtle Assessment Program, University of Rhode Island, Bureau of Land Management, Washington, DC.
- Chaloupka, M., and coauthors. 2008. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. *Global Ecology and Biogeography* 17(2):297-304.
- Chambers, R. C., D. D. Davis, E. A. Habeck, N. K. Roy, and I. Wirgin. 2012. Toxic effects of PCB126 and TCDD on shortnose sturgeon and Atlantic sturgeon. *Environmental Toxicology and Chemistry* 31(10):2324-2337.
- Chan, Y., and coauthors. 2025. Heavy metal concentrations suggest pollution risk varies between sea turtle species in the northwest Atlantic Ocean. *Chemosphere* 373:144190.
- Chapman, C. J., and A. D. Hawkins. 1973. Field study of hearing in cod, *Gadus morhua*-1. *Journal of Comparative Physiology* 85(2):147-167.
- Chapman, D. D., and coauthors. 2011. Genetic diversity despite population collapse in a critically endangered marine fish: the smalltooth sawfish (*Pristis pectinata*). *Journal of Heredity* 102(6):643-652.
- Charif, R. A., D. K. Mellinger, K. J. Dunsmore, K. M. Fristrup, and C. W. Clark. 2002. Estimated source levels of fin whale (*Balaenoptera physalus*) vocalizations: Adjustments for surface interference. *Marine Mammal Science* 18(1):81-98.
- Charifi, M., and coauthors. 2018. Noise pollution limits metal bioaccumulation and growth rate in a filter feeder, the Pacific oyster *Magallana gigas*. *PLoS One* 13(4):e0194174.
- Chen, C., T. Leu, S. Joung, and N. Lo. 1990. Age and growth of the scalloped hammerhead, *Sphyrna lewini*, in northeastern Taiwan waters.
- Chen, T. L., and coauthors. 2009. Particulate hexavalent chromium is cytotoxic and genotoxic to the North Atlantic right whale (*Eubalaena glacialis*) lung and skin fibroblasts. *Environmental and Molecular Mutagenesis* 50(5):387-393.
- Cheng, L., and coauthors. 2022. Past and future ocean warming. *Nature Reviews Earth & Environment* 2022 3:11 3(11).

- Chesapeake Biological Laboratory. 1948. Effects of Underwater Explosions on Oysters, Crabs and Fish: a Preliminary Report. Department of Research and Education, Publication No. 70, Solomons Island, MD.
- Chiappone, M., S. L. Miller, and D. W. Swanson. 2002. Status of *Acropora* corals in the Florida Keys: Habitat utilization, coverage, colony density, and juvenile recruitment. Pages 125-135 in Caribbean *Acropora* workshop: Potential Application of the US Endangered Species Act as a Conservation Strategy. NOAA, NMFS, Office of Protected Resources, Silver Spring, Maryland.
- Chow, J. C., P. E. Anderson, and A. M. Shedlock. 2019. Sea turtle population genomic discovery: Global and locus-specific signatures of polymorphism, selection, and adaptive potential. *Genome Biology and Evolution* 11(10):2797-2806.
- Christiansen, F., and coauthors. 2020. Population comparison of right whale body condition reveals poor state of the North Atlantic right whale. *Marine Ecology Progress Series* 640:1-16.
- Christiansen, F., and coauthors. 2016. Spatial variation in directional swimming enables juvenile sea turtles to reach and remain in productive waters. *Marine Ecology Progress Series*, 557, 247–259. .
- CITES. 2013. Consideration of Proposals for Amendment of Appendices I and II: Proposal Summary--Manta Rays *Manta* spp. Convention on International Trade in Endangered Species of Wild Fauna and Flora.
- Clapham, P. J., S. B. Young, and R. L. Brownell Jr. 1999. Baleen whales: Conservation issues and the status of the most endangered populations. *Mammal Review* 29(1):35-60.
- Claridge, D., and J. Durban. 2009. Monitoring beaked whale movements during submarine commanders course using satellite telemetry tags. Office of Naval Research.
- Claridge, D. E., C. A. Dunn, and J. W. Durban. 2009. Photographic mark-recapture reveals turnover of beaked whales on an active sonar range. Pages 57 in Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada.
- Clark, C., and coauthors. 2009a. Acoustic masking of baleen whale communications: Potential impacts from anthropogenic sources. Pages 56 in Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada.
- Clark, C. W., J. F. Borsani, and G. Notarbartolo-Di-Sciara. 2002. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. *Marine Mammal Science* 18(1):286-295.
- Clark, C. W., and R. A. Charif. 1998. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997. JNCC Report No. 281.
- Clark, C. W., and coauthors. 2009b. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. *Marine Ecology Progress Series* 395:201-222.
- Clark, C. W., and coauthors. 2009c. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. *Marine Ecology Progress Series* 395:201–222.
- Clark, C. W., and G. J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. *Journal of Underwater Acoustics (USN)* 52(3):48.
- Clark, T. B. 2010. Abundance, home range, and movement patterns of manta rays (*Manta alfredi*, *M. birostris*) in Hawai‘i. [Honolulu]:[University of Hawaii at Manoa],[December 2010].

- Clarke, C. R., and coauthors. 2015. Global mitochondrial DNA phylogeography and population structure of the silky shark, *Carcharhinus falciformis*. *Marine Biology* 162(5):945-955.
- Clarke, M. R. 1976. Observations on sperm whale diving. *Journal of the Marine Biological Association of the United Kingdom* 56(3):809-810.
- Clavero, M., and E. García-Berthou. 2005. Invasive species are a leading cause of animal extinctions. *Trends in Ecology and Evolution* 20(3):110.
- Clement, D. 2013. Effects on Marine Mammals. Ministry for Primary Industries. Literature review of ecological effects of aquaculture. Report prepared by Cawthron Institute, Nelson, New Zealand.
- Clyne, H., R. Leaper, and J. Kennedy. 1999. Computer simulation of interactions between the North Atlantic right whale (*Eubalaena glacialis*) and shipping. *European Research on Cetaceans* 13:458.
- Coelho, R., and coauthors. 2009. Notes of the reproduction of the oceanic whitetip shark, *Carcharhinus longimanus*, in the southwestern equatorial Atlantic Ocean. . Pages 1734-1740 in.
- Cole, T. V. N., and coauthors. 2013. Evidence of a North Atlantic right whale *Eubalaena glacialis* mating ground. *Endangered Species Research* 21(1):55-64.
- Coleman, N., and coauthors. 2024. Spawning run estimates and phenology for an extremely small population of Atlantic Sturgeon in the Marshyhope Creek–Nanticoke River system, Chesapeake Bay. *Marine and Coastal Fisheries* 16(3):e10292.
- Colgan, M. W. 1987. Coral reef recovery on Guam (Micronesia) after catastrophic predation by *Acanthaster planci*.
- Collins, M. R., S. G. Rogers, T. I. Smith, and M. L. Moser. 2000. Primary factors affecting sturgeon populations in the southeastern United States: fishing mortality and degradation of essential habitats. *Bulletin of Marine Science* 66(3):917-928.
- Collins, M. R., S. G. Rogers, and T. I. J. Smith. 1996. Bycatch of sturgeons along the southern Atlantic coast of the USA. *North American Journal of Fisheries Management* 16(1):24 - 29.
- Compa, M., and coauthors. 2022. Multispecies assessment of anthropogenic particle ingestion in a marine protected area. *Biology* 11(10):1375.
- Compagno, L. 1984. FAO Species Catalogue. Vol 4. Sharks of the world: an annotated and illustrated catalogue of shark species known to date. Parts 1 and 2. FAO Fisheries Synopsis No. 125., volume 4. FAO, Rome, Italy.
- Conn, P. B., and G. K. Silber. 2013. Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. *Ecosphere* 4(4):art43.
- Constantine, R., T. Iwata, S. L. Nieukirk, and G. S. Penry. 2018. Future directions in research on Bryde's whales. *Frontiers in Marine Science* 5:333.
- Constantine, R., and coauthors. 2015. Mitigation of vessel-strike mortality of endangered Bryde's whales in the Hauraki Gulf, New Zealand. *Biological Conservation* 186:149-157.
- Cooke, J. G. 2018. *Balaenoptera musculus* (errata version published in 2019).
- Cope, W., and coauthors. 2011. Assessing water quality suitability for shortnose sturgeon in the Roanoke River, North Carolina, USA with an in situ bioassay approach. *Journal of Applied Ichthyology* 27(1):1-12.
- Corey, F. C. G., R. H. Draeger, O. A. Brines, J. S. Shaver, and E. L. 1943. An experimental study of concussion. *United States Naval Medical Bulletin* 41(1):339-352.

- Corinaldesi, C., F. Marcellini, E. Nepote, E. Damiani, and R. Danovaro. 2018. Impact of inorganic UV filters contained in sunscreen products on tropical stony corals (*Acropora* spp.). *Science of the Total Environment* 2018:1279–1285.
- Corkeron, P., and coauthors. 2018. The recovery of North Atlantic right whales, *Eubalaena glacialis*, has been constrained by human-caused mortality. *Royal Society Open Science* 5(11):180892.
- Costa, D. P., and coauthors. 2016. Assessing the exposure of animals to acoustic disturbance: towards an understanding of the population consequences of disturbance. *Proceedings of Meetings on Acoustics*. AIP Publishing.
- Couturier, L. I., and coauthors. 2012. Biology, ecology and conservation of the Mobulidae. *Journal of Fish Biology* 80(5):1075-1119.
- Couturier, L. I., and coauthors. 2013. Stable isotope and signature fatty acid analyses suggest reef manta rays feed on demersal zooplankton. *PLoS One* 8(10):e77152.
- Cowan, C. 2024. Email from Christy Cowan (Navy, U.S. Fleet Forces Command) to Ron Salz (NMFS, Office of Protected Resources) regarding Navy vessel strikes in the AFTT action area.
- Craig, J. K., and coauthors. 2001. Ecological effects of hypoxia on fish, sea turtles, and marine mammals in the northwestern Gulf of Mexico. American Geophysical Union, Washington, D.C.
- Cranford, T. W. 1992. Functional morphology of the odontocete forehead: Implications for sound generation. University of California at Santa Cruz, Santa Cruz, California.
- Cranford, T. W., and P. Krysl. 2015. Fin whale sound reception mechanisms: Skull vibration enables low-frequency hearing. *PLoS One* 10(1):e116222.
- Croll, D. A., and coauthors. 2002. Only male fin whales sing loud songs. *Nature* 417:809.
- Croll, D. A., C. W. Clark, J. Calambokidis, W. T. Ellison, and B. R. Tershy. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. *Animal Conservation* 4(1):13-27.
- Croquer, A., F. Cavada-Blanco, A. L. Zubillaga, E. A. Agudo-Adriani, and M. Sweet. 2016. Is *Acropora palmata* recovering? A case study in Los Roques National Park, Venezuela. *PeerJ* 4:e1539.
- Crossman, C. A., and coauthors. 2024. Effects of inbreeding on reproductive success in endangered North Atlantic right whales. *Royal Society Open Science* 11(7):240490.
- Crum, N., T. Gowan, A. Krzystan, and J. Martin. 2019. Quantifying risk of whale–vessel collisions across space, time, and management policies. *Ecosphere* 10(4):e02713.
- Cruz-Piñón, G., J. P. Carricart-Ganivet, and J. Espinoza-Avalos. 2003. Monthly skeletal extension rates of the hermatypic corals *Montastraea annularis* and *Montastraea faveolata*: Biological and environmental controls. *Marine Biology* 143(3):491-500.
- Cummings, W. C., and P. O. Thompson. 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. *Journal of the Acoustical Society of America* 50(4B):1193-1198.
- Cummings, W. C., and P. O. Thompson. 1994. Characteristics and seasons of blue and finback whale sounds along the U.S. west coast as recorded at SOSUS stations. *Journal of the Acoustical Society of America* 95:2853.
- Cunningham, K. A., B. L. Southall, and C. Reichmuth. 2014. Auditory sensitivity of seals and sea lions in complex listening scenarios. *Journal of the Acoustical Society of America* 136(6):3410-3421.

- Cusano, D., L. Conger, S. Van Parijs, and S. Parks. 2019. Implementing conservation measures for the North Atlantic right whale: considering the behavioral ontogeny of mother-calf pairs. *Animal Conservation* 22(3):228-237.
- Czapanskiy, M. F., and coauthors. 2021. Modelling short-term energetic costs of sonar disturbance to cetaceans using high-resolution foraging data. *Journal of Applied Ecology*.
- D'Antonio, N. L., D. S. Gilliam, and B. K. Walker. 2016. Investigating the spatial distribution and effects of nearshore topography on *Acropora cervicornis* abundance in Southeast Florida. *PeerJ* 4:e2473.
- Dadswell, M. J. 1979. Biology and population characteristics of the shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818 (Osteichthyes: Acipenseridae), in the Saint John River Estuary, New Brunswick, Canada. *Canadian Journal of Zoology* 57:2186-2210.
- Dagorn, L., K. N. Holland, V. Restrepo, and G. Moreno. 2013. Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? *Fish and Fisheries* 14(3):391-415.
- Dahl, P. H., and coauthors. 2020. Physical effects of sound exposure from underwater explosions on Pacific sardines (*Sardinops sagax*). *The Journal of Acoustical Society of America* 147(4):2383-2395.
- Dahlgren, C., V. Pizarro, K. Sherman, W. Greene, and J. Oliver. 2021. Spatial and Temporal Patterns of Stony Coral Tissue Loss Disease Outbreaks in The Bahamas. *Frontiers in Marine Science* 8.
- Damon-Randall, K., and coauthors. 2010. Atlantic sturgeon research techniques. NOAA Technical Memorandum NMFS-NE 215:64pp.
- Danner, G. R., J. Chacko, and F. Brautigam. 2009. Voluntary ingestion of soft plastic fishing lures affects brook trout growth in the laboratory. *North American Journal of Fisheries Management* 29(2):352-360.
- Davenport, J., J. Wrench, J. McEvoy, and V. Carnacho-Ibar. 1990. Metal and PCB concentrations in the "Harlech" leatherback. *Marine Turtle Newsletter* 48:1-6.
- Davies, H. L., and coauthors. 2024. Marine and Freshwater Sounds Impact Invertebrate Behavior and Physiology: A Meta-Analysis. *Global Change Biology* 30(11):e17593.
- Davies, K. T., and coauthors. 2019. Variation in North Atlantic right whale *Eubalaena glacialis* occurrence in the Bay of Fundy, Canada, over three decades. *Endangered Species Research* 39:159-171.
- Davis, G. E. 1982. A century of natural change in coral distribution at the Dry Tortugas: A comparison of reef maps from 1881 and 1976. *Bulletin of Marine Science* 32(2):608-623.
- Davis, G. E., and coauthors. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014. *Scientific Reports* 7(1):13460.
- Day, R. D., A. L. Segars, M. D. Arendt, A. M. Lee, and M. M. Peden-Adams. 2007. Relationship of blood mercury levels to health parameters in the loggerhead sea turtle (*Caretta caretta*). *Environmental Health Perspectives* 115(10):1421.
- De Boer, M., J. Saulino, T. Lewis, and G. Notarbartolo-Di-Sciara. 2015. New records of whale shark (*Rhincodon typus*), giant manta ray (*Manta birostris*) and Chilean devil ray (*Mobula tarapacana*) for Suriname. *Marine Biodiversity Records* 8.

- de Soysa, T. Y., and coauthors. 2012. Macondo crude oil from the Deepwater Horizon oil spill disrupts specific developmental processes during zebrafish embryogenesis. *BMC Biology* 10(40):25.
- de Stephanis, R., J. Giménez, E. Carpinelli, C. Gutierrez-Exposito, and A. Cañadas. 2013. As main meal for sperm whales: Plastics debris. *Marine Pollution Bulletin* 69(1-2):206-214.
- Deakos, M. H., J. D. Baker, and L. Bejder. 2011. Characteristics of a manta ray *Manta alfredi* population off Maui, Hawaii, and implications for management. *Marine Ecology Progress Series* 429:245–260.
- Deakos, M. H., and M. F. Richlen. 2015. Vessel-Based Marine Mammal Survey on the Navy Range off Kauai in Support of Passive Acoustic Monitoring and Satellite-Tagging Efforts: 1–9 February 2014 (Prepared for Naval Facilities Engineering Command Pacific for Commander, U.S. Pacific Fleet under Contract No. N62470-10-D-3011, CTO KB22). Honolulu, HI: HDR Inc.
- DeAngelis, B. M. 2006. The Distribution of Elasmobranchs in St. Thomas and St. John, United States Virgin Islands with an Emphasis on Shark Nursery Areas. University of Rhode Island, Rhode Island.
- Dearden, E. K. 2025. Singing Activity of Humpback Whales (Breeding Stock G) at Two Locations with Varied Boat Activity along the Pacific Coast of Costa Rica. UVM Patrick Leahy Honors College Senior Theses.
- Deem, S. L., and coauthors. 2006. Blood values in free-ranging nesting leatherback sea turtles (*Dermochelys coriacea*) on the coast of the Republic of Gabon. *Journal of Zoo and Wildlife Medicine* 37(4):464-471.
- Denison, C. D., and coauthors. 2025. Using side-scan sonar to estimate the abundance of dual-spawning Atlantic Sturgeon in the Great Pee Dee River, South Carolina. *Transactions of the American Fisheries Society*:vna013.
- Denkinger, J., and coauthors. 2013. Are boat strikes a threat to sea turtles in the Galapagos Marine Reserve? *Ocean & coastal management* 80:29-35.
- Derraik, J. G. B. 2002. The pollution of the marine environment by plastic debris: A review. *Marine Pollution Bulletin* 44(9):842-852.
- DeRuiter, S. L., and K. L. Doukara. 2012. Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research* 16:55-63.
- DeRuiter, S. L., and coauthors. 2017. A multivariate mixed hidden Markov model for blue whale behaviour and responses to sound exposure. *The Annals of Applied Statistics* 11(1):362-392.
- Dewar, H., and coauthors. 2008. Movements and site fidelity of the giant manta ray, *Manta birostris*, in the Komodo Marine Park, Indonesia. *Marine Biology* 155(2):121-133.
- Di Lorio, L., and C. W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters* 6:51–54.
- Díaz, M. P., H. P. Kunc, and J. D. Houghton. 2024. Anthropogenic noise predicts sea turtle behavioural responses. *Marine Pollution Bulletin* 198:115907.
- Dickerson. 2006. Observed takes of sturgeon and turtles from dredging operations along the Atlantic Coast.
- Dickerson, D., and coauthors. 2007. Effectiveness of relocation trawling during hopper dredging for reducing incidental take of sea turtles. Pages 509-530 in R. E. Randell, editor 2007 World Dredging Conference, Lake Buena Vista, Florida.

- Dickerson, D. D., and T. Bargo. 2012. Occurrence of a sea turtle congregation near Louisiana Chandeleur Islands following the *Deepwater Horizon* oil spill. Pages 11 in T. T. Jones, and B. P. Wallace, editors. Thirty-First Annual Symposium on Sea Turtle Biology and Conservation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, San Diego, California.
- DiJohnson, A. M. 2019. Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) behavioral responses to vessel traffic and habitat use in the Delaware River, USA. Master's Thesis. Delaware State University, Dover, DE.
- DiMatteo, A., and coauthors. 2024. Sea turtle density surface models along the United States Atlantic coast. *Endangered Species Research* 53:227-245.
- Doblin, M. A., and coauthors. 2004. Transport of the Harmful Bloom Alga *Aureococcus anophagefferens* by Oceangoing Ships and Coastal Boats. *Applied and Environmental Microbiology* 70(11):6495-6500.
- Dombroski, J. R., S. E. Parks, and D. P. Nowacek. 2021. Dive behavior of North Atlantic right whales on the calving ground in the Southeast USA: implications for conservation. *Endangered Species Research* 46:35-48.
- Dow Piniak, W. E., S. A. Eckert, C. A. Harms, and E. M. Stringer. 2012. Underwater hearing sensitivity of the leatherback sea turtle (*Dermochelys coriacea*): Assessing the potential effect of anthropogenic noise. U.S. Dept of the Interior, Bureau of Ocean Energy Management, Headquarters, Herndon, VA.
- Downs, C. A., and coauthors. 2016. Toxicopathological Effects of the Sunscreen UV Filter, Oxybenzone (Benzophenone-3), on Coral Planulae and Cultured Primary Cells and Its Environmental Contamination in Hawaii and the U.S. Virgin Islands. *Archives of Environmental Contamination and Toxicology* 2016(70):265–288.
- Doyle, L. R., and coauthors. 2008. Applicability of information theory to the quantification of responses to anthropogenic noise by southeast Alaskan humpback whales. *Entropy* 10(2-Jan):33-46.
- Duarte, C. M., and coauthors. 2021. The soundscape of the Anthropocene ocean. *Science* 371(6529):eaba4658.
- DuBois, M. J., N. F. Putman, and S. E. Piacenza. 2020. Hurricane frequency and intensity may decrease dispersal of Kemp's ridley sea turtle hatchlings in the Gulf of Mexico. *Frontiers in Marine Science* 7:301.
- DuBois, M. J., N. F. Putman, and S. E. Piacenza. 2021. A global assessment of the potential for ocean-driven transport in hatchling sea turtles. *Water* 13(6):757.
- Dudley, S. F., and C. A. Simpfendorfer. 2006. Population status of 14 shark species caught in the protective gillnets off KwaZulu–Natal beaches, South Africa, 1978–2003. *Marine and Freshwater Research* 57(2):225-240.
- Duffy, C., and D. Abbott. 2003. Sightings of mobulid rays from northern New Zealand, with confirmation of the occurrence of *Manta birostris* in New Zealand waters.
- Dulvy, N. K., S. A. Pardo, C. A. Simpfendorfer, and J. K. Carlson. 2014. Diagnosing the dangerous demography of manta rays using life history theory. *PeerJ* 2:e400.
- Duncan, K. M., and K. N. Holland. 2006. Habitat use, growth rates and dispersal patterns of juvenile scalloped hammerhead sharks *Sphyrna lewini* in a nursery habitat. *Marine Ecology Progress Series* 312:211-221.
- Dunlop, R. A. 2016. The effect of vessel noise on humpback whale, *Megaptera novaeangliae*, communication behaviour. *Animal Behaviour* 111:13-21.

- Dunlop, R. A., J. Braithwaite, L. O. Mortensen, and C. M. Harris. 2021. Assessing population-level effects of anthropogenic disturbance on a marine mammal population. *Frontiers in Marine Science* 8:624981.
- Dunlop, R. A., D. Cato, and M. J. Noad. 2010. Your attention please: increasing ambient noise levels elicit a change in communication behaviour in humpback whales (*Megoptera novaeangliae*). *Proceedings of the Royal Society B*, 277, 2521–2529. .
- Dunlop, R. A., and coauthors. 2017. Determining the behavioural dose-response relationship of marine mammals to air gun noise and source proximity. *Journal of Experimental Biology* 220(16):2878–2886.
- Durbach, I. N., and coauthors. 2021. Changes in the Movement and Calling Behavior of Minke Whales (*Balaenoptera acutorostrata*) in Response to Navy Training. *Frontiers in Marine Science* 8.
- Dutton, P. H., V. Pease, and D. Shaver. 2006. Characterization of mtDNA variation among Kemp's ridleys nesting on Padre Island with reference to Rancho Nuevo genetic stock. Pages 189 in *Twenty-Sixth Annual Conference on Sea Turtle Conservation and Biology*.
- DWH-MMIQT. 2015. Models and Analyses for the Quantification of Injury to Gulf of Mexico Cetaceans from the Deepwater Horizon Oil Spill. DWH Marine Mammal NRDA Technical Working Group Report, Prepared by: the Deepwater Horizon Marine Mammal Injury Quantification Team (DWH MMIQT).
- DWHTrustees. 2016. *Deepwater Horizon* Oil Spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. Deepwater Horizon Natural Resource Damage Assessment Trustees.
- Dwyer, F., and coauthors. 2005. Assessing contaminant sensitivity of endangered and threatened aquatic species: Part III. Effluent toxicity tests. *Archives of Environmental Contamination and Toxicology* 48(2):174-183.
- Eckert, K., B. Wallace, J. Frazier, S. Eckert, and P. Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*) U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication, BTP-R4015-2012, Washington, District of Columbia.
- Eckert, S. A. 2002. Swim speed and movement patterns of gravid leatherback sea turtles (*Dermochelys coriacea*) at St Croix, US Virgin Islands. *Journal of Experimental Biology* 205(23):3689-3697.
- Edds-Walton, P. L. 1997. Acoustic communication signals of mysticete whales. *Bioacoustics-the International Journal of Animal Sound and Its Recording* 8:47-60.
- Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence estuary. *Bioacoustics* 1:131-149.
- Edmunds, P. J. 2014. Large numbers of *Acropora palmata* grow in shallow water in St. John, US Virgin Islands. *Bulletin of Marine Science* 90(4):999-1000.
- Edmunds, P. J. 2015. A quarter-century demographic analysis of the Caribbean coral, *Orbicella annularis*, and projections of population size over the next century. *Limnology and Oceanography* 60(3):840-855.
- Edmunds, P. J. 2019. The demography of hurricane effects on two coral populations differing in dynamics. *Ecosphere* 10(9):e02836.
- Edwards, E. F., C. Hall, T. J. Moore, C. Sheredy, and J. V. Redfern. 2015. Global distribution of fin whales (*Balaenoptera physalus*) in the post-whaling era (1980–2012). *Mammal Review* 45(4):197-214.

- Edwards, M. H., and coauthors. 2016. The Hawaii Undersea Military Munitions Assessment. Deep-Sea Research II, 128, 4–13.
- Edwards, M. L., M. T. Balazik, C. W. Bangley, R. Aguilar, and M. B. Ogburn. 2020. Detection of a mature Atlantic sturgeon in the Patuxent River, Maryland, using passive acoustic telemetry. Northeastern naturalist 27(4):792-802.
- Edwards, R. E., F. M. Parauka, and K. J. Sulak. 2007. New insights into marine migration and winter habitat of Gulf sturgeon. American Fisheries Society Symposium 57:14.
- Efroymson, R. A., G. W. Suter II, W. H. Rose, and S. Nemeth. 2001. Ecological risk assessment framework for low-altitude aircraft overflights: I planning the analysis and estimating exposure. Risk Analysis 21:251-262.
- Egusa, S., and V. Kothekar. 1992. Infectious diseases of fish. AA Balkema.
- Eller, A. I., and R. C. Cavanagh. 2000. Subsonic Aircraft Noise At and Beneath the Ocean Surface: Estimation of Risk for Effects on Marine Mammals. United States Air Force Research Laboratory.
- Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology 26(1):21-28.
- Endres, C. S., and coauthors. 2016. Multi-Modal Homing in Sea Turtles: Modeling Dual Use of Geomagnetic and Chemical Cues in Island-Finding. Front Behav Neurosci 10:19.
- Engas, A., E. Haugland, and J. Ovredal. 1998. Reactions of Cod (*Gadus Morhua* L.) in the Pre-Vessel Zone to an Approaching Trawler under Different Light Conditions. Hydrobiologia, 371/372: 199–206. .
- Engas, A., O. Misund, A. Soldal, B. Horvei, and A. Solstad. 1995. Reactions of Penned Herring and Cod to Playback of Original, Frequency-Filtered and Time-Smoothed Vessel Sound. Fisheries Research, 22: 243–54. .
- Engelhaupt, D., and coauthors. 2009. Female philopatry in coastal basins and male dispersion across the North Atlantic in a highly mobile marine species, the sperm whale (*Physeter macrocephalus*). Molecular Ecology 18(20):4193-4205.
- Engelhaupt, D. T., and coauthors. 2020. Blue whale (*Balaenoptera musculus*) sightings off the coast of Virginia. Marine Biodiversity Records 13(1):6.
- Enger, P. S. 1981. Frequency discrimination in teleosts-central or peripheral?, New York, Spring Verlag.
- Ennis, R. S., M. E. Brandt, K. E. W. Grimes, and T. B. Smith. 2016. Coral reef health response to chronic and acute changes in water quality in St. Thomas, United States Virgin Islands. Marine Pollution Bulletin 111(1–2):418–427.
- EPA. 2024. Threats to Coral Reefs.
- Epperly, S. P., J. Braun, and A. J. Chester. 1995. Aerial surveys for sea turtles in North Carolina inshore waters. Fishery Bulletin 93(2):254-261.
- Epperly, S. P., and coauthors. 1996. Beach strandings as an indicator of at-sea mortality of sea turtles. Bulletin of Marine Science 59(2):289-297.
- Erbe, C. 2002. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.
- Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. 2015. Communication masking in marine mammals: a review and research strategy. Marine Pollution Bulletin, 1–24.

- Esbaugh, A. J., and coauthors. 2016. The effects of weathering and chemical dispersion on Deepwater Horizon crude oil toxicity to mahi-mahi (*Coryphaena hippurus*) early life stages. *Sci Total Environ* 543(Pt A):644-651.
- Estabrook, B. J., D. W. Ponirakis, C. W. Clark, and A. N. Rice. 2016. Widespread spatial and temporal extent of anthropogenic noise across the northeastern Gulf of Mexico shelf ecosystem. *Endangered Species Research* 30:267-282.
- Esteban, N., and coauthors. 2020. A global review of green turtle diet: sea surface temperature as a potential driver of omnivory levels. *Marine Biology* 167:1-17.
- Estrada-Saldívar, N., B. A. Quiroga-García, E. Pérez-Cervantes, O. O. Rivera-Garibay, and L. Alvarez-Filip. 2021. Effects of the Stony Coral Tissue Loss Disease Outbreak on Coral Communities and the Benthic Composition of Cozumel Reefs. *Frontiers in Marine Science* 8.
- Evans, P. G. H., and A. Bjørge. 2013. Impacts of climate change on marine mammals. *Marine Climate Change Impacts Partnership: Science Review*:134-148.
- Evans, T., N. Record, C. Ross, and L. Thorne. 2025. Beyond Calanus: changes to the copepod community in the northeast USA and implications for North Atlantic right whale foraging energetics. *Endangered Species Research* 56:1-17.
- Fair, P. A., and coauthors. 2014. Stress response of wild bottlenose dolphins (*Tursiops truncatus*) during capture-release health assessment studies. *General and Comparative Endocrinology* 206:203-212.
- Fairbanks, R. G. 1989. A 17,000-year glacio-eustatic sea level record: Influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation. *Nature* 342(6250):637-642.
- Farmer, N. A., and J. C. Doerr. 2022. Limiting factors for queen conch (*Lobatus gigas*) reproduction: A simulation-based evaluation. *PLoS One* 17(3):e0251219.
- Farmer, N. A., and coauthors. 2022a. The distribution of manta rays in the western North Atlantic Ocean off the eastern United States. *Scientific Reports* 12.
- Farmer, N. A., D. P. Noren, E. M. Fougères, A. Machernis, and K. Baker. 2018. Resilience of the endangered sperm whale *Physeter macrocephalus* to foraging disturbance in the Gulf of Mexico, USA: A bioenergetic approach. *Marine Ecology Progress Series* 589:241-261.
- Farmer, N. A., and coauthors. 2022b. Modeling protected species distributions and habitats to inform siting and management of pioneering ocean industries: A case study for Gulf of Mexico aquaculture. *PLoS One* 17(9):e0267333.
- Farrae, D. J., W. C. Post, and T. L. Darden. 2017. Genetic characterization of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, in the Edisto River, South Carolina and identification of genetically discrete fall and spring spawning. *Conservation Genetics*:1-11.
- Fay, C., and coauthors. 2006. Status review for anadromous Atlantic salmon (*Salmo salar*) in the United States.
- Felix, A., M. E. Stevens, and R. L. Wallace. 1995. Unpalatability of a colonial rotifer, *Sinantherina socialis*, to small zooplanktivorous fishes. *Invertebrate Biology* 114(2):139-144.
- Ferguson, M. C., J. Barlow, P. Feidler, S. B. Reilly, and T. Gerrodette. 2006. Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern Pacific Ocean. *Ecological Modelling* 193:645-662.
- Ferrier-Pagès, C., and coauthors. 2021. Noise pollution on coral reefs?—A yet underestimated threat to coral reef communities. *Marine Pollution Bulletin* 165:112129.

- Fields, C. Y., and coauthors. 2025. Mixed stock analysis of major markets and trade records reveals illegal trade of oceanic whitetip shark fins from the Atlantic ocean. *Conservation Genetics*:1-10.
- Figueiredo, L. D. d., and coauthors. 2014. Site Fidelity of Bryde's Whales (*Balaenoptera edeni*) in Cabo Frio Region, Southeastern Brazil, through photoidentification technique. *Brazilian Journal of Aquatic Science and Technology* 18(2):59-64.
- Finkbeiner, E. M., and coauthors. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. *Biological Conservation*.
- Finneran, J., and B. Branstetter. 2013. Effects of Noise on Sound Perception in Marine Mammals. *Animal Communication and Noise* (Vol. 2, pp. 273–308). Springer Berlin Heidelb.
- Finneran, J. J. 2015. Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. *Journal of the Acoustical Society of America* 138(3):1702-1726.
- Finneran, J. J. 2018. Conditioned attenuation of auditory brainstem responses in dolphins warned of an intense noise exposure: Temporal and spectral patterns. *J Acoust Soc Am* 143(2):795.
- Finneran, J. J., and A. K. Jenkins. 2012. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis, San Diego, CA.
- Fisher, W. S., and coauthors. 2014. Regional status assessment of stony corals in the US Virgin Islands. *Environ Monit Assess* 186(11):7165-81.
- Flanigan, A. J., N. G. Perlut, and J. A. Sulikowski. 2021. A preliminary abundance estimate of an atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) contingent within an open riverine system.
- Flewelling, L. J., and coauthors. 2005. Brevetoxicosis: red tides and marine mammal mortalities. *Nature* 435(7043):755.
- Flinn, R. D., A. W. Trites, E. J. Gregr, and R. I. Perry. 2002. Diets of fin, sei, and sperm whales in British Columbia: an analysis of commercial whaling records, 1963–1967. *Marine Mammal Science* 18(3):663-679.
- Florida Fish and Wildlife Conservation Commission. 2013. A Species Action Plan for the Pillar Coral *Dendrogyra cylindrus*, Final Draft. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.
- Fogarty, N. D., S. V. Vollmer, and D. R. Levitan. 2012. Weak Prezygotic Isolating Mechanisms in Threatened Caribbean *Acropora* Corals. *PLoS One* 7(2):e30486.
- Foley, A. M., B. A. Schroeder, A. E. Redlow, K. J. Fick-Child, and W. G. Teas. 2005. Fibropapillomatosis in stranded green turtles (*Chelonia mydas*) from the eastern United States (1980–98): trends and associations with environmental factors. *Journal of Wildlife Diseases* 41(1):29-41.
- Foley, A. M., and coauthors. 2019. Characterizing watercraft-related mortality of sea turtles in Florida. *The Journal of Wildlife Management* 83(5):1057-1072.
- Fong, P., and D. Lirman. 1995. Hurricanes cause population expansion of the branching coral *Acropora palmata* (Scleractinia): Wound healing and growth patterns of asexual recruits. *Marine Ecology* 16(4):317-335.
- Fonnesbeck, C. J., L. P. Garrison, L. I. Ward-Geiger, and R. D. Baumstark. 2008. Bayesian hierarchical model for evaluating the risk of vessel strikes on North Atlantic right whales in the SE United States. *Endangered Species Research* 6(1):87-94.

- Foote, A. D., R. W. Osborne, and A. R. Hoelzel. 2004. Whale-call response to masking boat noise. *Nature* 428(6986):910.
- Force, U. S. D. o. t. A. 1997. Environmental effects of self-protection chaff and flares. Langley Air Force Base, VA: U.S. Department of the Air Force.
- Ford, J. K., and R. R. Reeves. 2008. Fight or flight: antipredator strategies of baleen whales. *Mammal Review* 38(1):50-86.
- Formicki, K., A. Korzelecka-Orkisz, and A. Tański. 2019. Magnetoreception in fish. *Journal of Fish Biology* 95(1):73-91.
- Forney, K. A., and coauthors. 2017. Nowhere to go: noise impact assessments for marine mammal populations with high site fidelity. *Endangered Species Research* 32:391-413.
- Fortune, S. M. E., A. W. Trites, C. A. Mayo, D. A. S. Rosen, and P. K. Hamilton. 2013. Energetic requirements of North Atlantic right whales and the implications for species recovery. *Marine Ecology Progress Series* 478:253-272.
- Fortune, S. M. E., and coauthors. 2012. Growth and rapid early development of North Atlantic right whales (*Eubalaena glacialis*). *Journal of Mammalogy* 93(5):1342-1354.
- Foster, A. M., and J. P. Clugston. 1997. Seasonal migration of Gulf sturgeon in the Suwannee River, Florida. *Transactions of the American Fisheries Society* 126(2):302-308.
- Fox, A., E. Stowe, and D. Peterson. 2016. Occurrence and movements of shortnose and Atlantic sturgeon in the St. Johns River, Florida. (Cooperative Agreement Award W9126G-13-2-0029). Jacksonville, Florida: Prepared for Naval Facilities Engineering Command, Southeast.
- Fox, A. G., D. Peterson, I. Wirgin, and A. Cummins. 2019. Quantifying Annual Recruitment and Nursery Habitats of Atlantic Sturgeon in Georgia. National Marine Fisheries Service.
- Fox, A. G., and D. L. Peterson. 2019. Movement and Out-Migration of Juvenile Atlantic Sturgeon in Georgia, USA. *Transactions of the American Fisheries Society* 148(5):952-962.
- Fox, A. G., I. I. Wirgin, and D. L. Peterson. 2018. Occurrence of Atlantic Sturgeon in the St. Marys River, Georgia. *Marine and Coastal Fisheries* 10(6):606-618.
- Fox, D. A., E. A. Hale, and J. A. Sweka. 2020. Examination of Atlantic sturgeon vessel strikes in the Delaware River Estuary. Final Report. Delaware State University, Dover, Delaware.
- Fox, D. A., J. E. Hightower, and F. M. Parauka. 2000. Gulf sturgeon spawning migration and habitat in the Choctawhatchee River system, Alabama–Florida. *Transactions of the American Fisheries Society* 129(3):811-826.
- Fox, D. A., J. E. Hightower, and F. M. Parauka. 2002. Estuarine and nearshore marine habitat use by Gulf sturgeon from the Choctawhatchee River system, Florida. Pages 111-126 *in* American Fisheries Society Symposium.
- Fox, H. E., and R. L. Caldwell. 2006. Recovery from blast fishing on coral reefs: A tale of two scales. *Ecological Applications* 16(5):1631–1635.
- Francis, C. D. J. R. B. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. *Frontiers in Ecology and the Environment* 11(6):305-313.
- Frankham, R., C. J. A. Bradshaw, and B. W. Brook. 2014. Genetics in conservation management: revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. *Biological Conservation* 170:56-63.
- Franklin, I. R. 1980. Evolutionary change in small populations. Pages 135-149 *in* M. E. Soulé, and B. A. Wilcox, editors. *Conservation Biology: An evolutionary-ecological perspective*. Sinauer Associates, Sunderland, MA.

- Frasier, K. E., and coauthors. 2024a. A decade of declines in toothed whale densities following the Deepwater Horizon oil spill. *Communications Earth & Environment* 5(1):782.
- Frasier, K. E., and coauthors. 2024b. LISTEN GoMex: 2020-2023 Long-term Investigations into Soundscapes, Trends, Ecosystems, and Noise in the Gulf of Mexico.
- Frédou, F. L., and coauthors. 2015. Sharks caught by the Brazilian tuna longline fleet: an overview. *Rev. Fish Biol. Fish.* 25:365-377.
- Freedman, R., and S. S. Roy. 2012. Spatial patterning of *Manta birostris* in United States east coast offshore habitat. *Applied Geography* 32(2):652-659.
- Fristrup, K. M., L. T. Hatch, and C. W. Clark. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. *Journal of the Acoustical Society of America* 113(6):3411-3424.
- Fuentes, M., and coauthors. 2024. Adaptation of sea turtles to climate warming: Will phenological responses be sufficient to counteract changes in reproductive output? *Global Change Biology* 30(1):e16991.
- Fuentes, M. M., and coauthors. 2020. Potential adaptability of marine turtles to climate change may be hindered by coastal development in the USA. *Regional Environmental Change* 20:1-14.
- Fuentes, M. M., and coauthors. 2023. Key issues in assessing threats to sea turtles: knowledge gaps and future directions. *Endangered Species Research* 52:303-341.
- Fujihara, J., T. Kunito, R. Kubota, and S. Tanabe. 2003. Arsenic accumulation in livers of pinnipeds, seabirds and sea turtles: Subcellular distribution and interaction between arsenobetaine and glycine betaine. *Comparative Biochemistry and Physiology C Toxicology and Pharmacology* 136(4):287-296.
- Fujiwara, M., and H. Caswell. 2001. Demography of the endangered North Atlantic right whale. *Nature* 414(6863):537-541.
- Fujiwara, M., and coauthors. 2019. Climate-related factors cause changes in the diversity of fish and invertebrates in subtropical coast of the Gulf of Mexico. *Communications Biology* 2(1).
- Furin, C. G., F. von Hippel, B. Hagedorn, and T. O'Hara. 2013. Perchlorate trophic transfer increases tissue concentrations above ambient water exposure alone in a predatory fish. *Journal of Toxicology and Environmental Health. Part A*, 76(18), 1072–1084. .
- Fuxjager, M. J., K. R. Davidoff, L. A. Mangiamale, and K. J. Lohmann. 2014. The geomagnetic environment in which sea turtle eggs incubate affects subsequent magnetic navigation behaviour of hatchlings. *Proceedings of the Royal Society B: Biological Sciences* 281(1791):20141218.
- Gabriele, C., B. Kipple, and C. Erbe. 2003. Underwater acoustic monitoring and estimated effects of vessel noise on humpback whales in Glacier Bay, Alaska. Pages 56-57 *in* Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.
- Gailani, J. Z., and coauthors. 2016. Predicting dredging-associated effects to coral reefs in Apra Harbor, Guam - Part 1: Sediment exposure modeling. *Journal of Environmental Management* 168:16–26.
- Gailey, G., B. Wursig, and T. L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast Sakhalin Island, Russia. *Environmental Monitoring and Assessment* 134:75–91.

- Gall, S. C., and R. C. Thompson. 2015. The impact of debris on marine life. *Marine Pollution Bulletin* 92(2-Jan):170-179.
- Gallagher, A. J., N. Hammerschlag, D. S. Shiffman, and S. T. Giery. 2014. Evolved for extinction: the cost and conservation implications of specialization in hammerhead sharks. *BioScience* 64(7):619-624.
- Gallagher, C. A., V. Grimm, L. A. Kyhn, C. C. Kinze, and J. Nabe-Nielsen. 2021. Movement and seasonal energetics mediate vulnerability to disturbance in marine mammal populations. *The American Naturalist* 197(3):296-311.
- Gallo, F., and coauthors. 2018. Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. *Environmental Sciences Europe* 30(1).
- Gambell, R. 1999. The International Whaling Commission and the contemporary whaling debate. Pages 179-198 in J. R. Twiss Jr., and R. R. Reeves, editors. *Conservation and Management of Marine Mammals*. Smithsonian Institution Press, Washington.
- Ganley, L. C., S. Brault, and C. A. Mayo. 2019. What we see is not what there is: estimating North Atlantic right whale *Eubalaena glacialis* local abundance. *Endangered Species Research* 38:101-113.
- GAO. 2024. Offshore Oil and Gas: Interior Needs to Improve Decommissioning Enforcement and Mitigate Related Risks, GAO-24-106229.
- Gao, Y., S. Wang, J. Zhang, X. Jia, and Z. Sheng. 2024. Influence of water depth on the peak overpressure and energy of the secondary pressure wave of underwater explosions. *Ocean Engineering* 293:116580.
- García-Fernández, A. J., and coauthors. 2009. Heavy metals in tissues from loggerhead turtles (*Caretta caretta*) from the southwestern Mediterranean (Spain). *Ecotoxicology and Environmental Safety* 72(2):557-563.
- García-Urueña, R., and M. A. Garzón-Machado. 2020. Current status of *Acropora palmata* and *Acropora cervicornis* in the Colombian Caribbean: demography, coral cover and condition assessment. *Hydrobiologia* 847(9):2141-2153.
- Gardner, S. C., M. D. Pier, R. Wesselman, and J. A. Juarez. 2003. Organochlorine contaminants in sea turtles from the Eastern Pacific. *Marine Pollution Bulletin* 46(9):1082-1089.
- Garrison, L., D. Glenn III, and H. Karrigan. 2019. The movement and habitat associations of sea turtles in the Northern Gulf of Mexico. New Orleans (LA): US Department of the Interior, Bureau of Ocean Energy Management:2020-010.
- Garrison, L. P., J. Adams, Patterson. E.M., and C. P. Good. 2022. Assessing the risk of vessel strike mortality in North Atlantic right whales along the U.S East Coast.
- Garrison, L. P., and coauthors. 2024a. The effects of vessel speed and size on the lethality of strikes of large whales in US waters. *Frontiers in Marine Science* 11:1467387.
- Garrison, L. P., J. Ortega-Ortiz, and G. Rappucci. 2020. Abundance of marine mammals in the waters of the U.S. Gulf of Mexico in the summer of 2017 and 2018. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, Florida 33140.
- Garrison, L. P., and coauthors. 2023a. Gulf of Mexico Marine Assessment Program for Protected Species (GOMMAPPS): marine mammals. Volume 2: appendix C: Gulf of Mexico marine mammal spatial density models. US Department of the Interior, Bureau of Ocean Energy Management, New Orleans (LA).

- Garrison, L. P., and coauthors. 2023b. Gulf of Mexico Marine Assessment Program for Protected Species (GOMMAPPS): marine mammals. Volume 3: appendix D: Gulf of Mexico sea turtle spatial density models. US Department of the Interior, Bureau of Ocean Energy Management, New Orleans (LA).
- Garrison, L. P., M. S. Soldevilla, A. Martinez, and K. D. Mullin. 2024b. A density surface model describing the habitat of the Critically Endangered Rice's whale *Balaenoptera ricei* in the Gulf of Mexico. *Endangered Species Research* 54:41-58.
- Garron, H. A., and coauthors. 2022. Serious injury and mortality determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2017-2021. U.S. Dept. of Commerce, Northeast Fisheries Science Center.
- Gaspin, J. B., G. B. Peters, and M. L. Wisely. 1976. Experimental Investigations of the Effects of Underwater Explosions on Swimbladder Fish. Naval Ordnance Lab, Silver Spring, MD.
- Gauthier, J. M., C. D. Metcalf, and R. Sears. 1997. Chlorinated organic contaminants in blubber biopsies from northwestern Atlantic balaenopterid whales summering in the Gulf of St Lawrence. *Marine Environmental Research* 44(2):201-223.
- Gende, S. M., and coauthors. 2011. A Bayesian approach for understanding the role of ship speed in whale-ship encounters. *Ecological Applications* 21(6):2232-2240.
- Gende, S. M., and coauthors. 2019. Active whale avoidance by large ships: components and constraints of a complementary approach to reducing ship strike risk. *Frontiers in Marine Science* 6:592.
- General. 1991. Conventional Warfare Ballistic, Blast, and Burn Injuries. Office of Surgeon General. In R. Zajitchuk, Col. (Ed.), U.S.A. Textbook of Military Medicine. Washington, DC: Office of the Surgeon General.
- Giesy, J. P., J. Newsted, and D. L. Garling. 1986. Relationships between chlorinated hydrocarbon concentrations and rearing mortality of chinook salmon (*Oncorhynchus tshawytscha*) eggs from Lake Michigan. *Journal of Great Lakes Research* 12(1):82-98.
- Gill, A. B., and M. Desender. 2020. 2020 State of the Science Report, chapter 5: risk to animals from electromagnetic fields emitted by electric cables and marine renewable energy devices.
- Gill, A. B., I. Gloyne-Philips, J. Kimber, and P. Sigray. 2014. Marine renewable energy, electromagnetic (EM) fields and EM-sensitive animals. *Marine renewable energy technology and environmental interactions*:61-79.
- Gilmore, M. D., and B. R. Hall. 1976. Life history, growth habits, and constructional roles of *Acropora cervicornis* in the patch reef environment. *Journal of Sedimentary Research* 46(3):519-522.
- Girondot, M., and coauthors. 2015. Spatio-temporal distribution of *Manta birostris* in French Guiana waters. *Journal of the Marine Biological Association of the United Kingdom* 95(1):153-160.
- Gitschlag, G. R., B. A. Herczeg, and T. R. Barcak. 1997. Observations of sea turtles and other marine life at the explosive removal of offshore oil and gas structures in the Gulf of Mexico. *Gulf Research Reports* 9(4):247-262.
- Gitschlag, G. R., M. J. Schirripa, and J. E. Powers. 2001. Estimation of fisheries impacts due to underwater explosives used to sever and salvage oil and gas platforms in the US Gulf of Mexico.
- GMFMC. 2010. Final Amendment 31 to the Fishery Management Plan for Reef Fish Resources in the Gulf of Mexico (Revised): Addresses Bycatch of Sea Turtles in the Bottom

- Longline Component of the Reef Fish Fishery. Gulf of Mexico Fishery Management Council Pursuant to National Oceanic and Atmospheric Administration Award No. NA05NMF4410003, Tampa, Florida.
- Godley, B. J., D. R. Thompson, and R. W. Furness. 1999. Do heavy metal concentrations pose a threat to marine turtles from the Mediterranean Sea? *Marine Pollution Bulletin* 38(6):497-502.
- Goergen, E. A., A. L. Moulding, B. K. Walker, and D. S. Gilliam. 2019. Identifying Causes of Temporal Changes in *Acropora cervicornis* Populations and the Potential for Recovery. *Frontiers in Marine Science* 6.
- Goergen, E. A., K. Semon Lunz, and D. S. Gilliam. 2020. Spatial and temporal differences in *Acropora cervicornis* colony size and health. Pages 83-114 in B. M. Riegl, editor. *Population Dynamics of the Reef Crisis*, volume 87. Academic Press.
- Goldberg, W. M. 1973. The ecology of the coral octocoral communities off the southeast Florida coast: Geomorphology, species composition and zonation. *Bulletin of Marine Science* 23:465-488.
- Goldbogen, J. a., and coauthors. 2013. Blue whales respond to simulated mid-frequency military sonar. *Proceedings of the Royal Society B: Biological Sciences* 280(1765):20130657.
- González-Díaz, P., and coauthors. 2018. Status of Cuban coral reefs. *Bulletin of Marine Science*.
- Goold, J. C. 1999. Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. *Journal of the Marine Biological Association of the United Kingdom* 79(3):541-550.
- Goold, J. C., and R. F. W. Coates. 2006. Near source, high frequency air-gun signatures. *International Whaling Commission*.
- Goold, J. C., and S. E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. *Journal of the Acoustical Society of America* 98(3):1279-1291.
- Gordon, A. N., A. R. Pople, and J. Ng. 1998. Trace metal concentrations in livers and kidneys of sea turtles from south-eastern Queensland, Australia. *Marine and Freshwater Research* 49(5):409-414.
- Gordon, J., and coauthors. 2003. A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal*, 37(4), 16–34.
- Gordon, J. C. D. 1987. The behaviour and ecology of sperm whales off Sri Lanka. (*Physeter macrocephalus*). University of Cambridge, Cambridge. 347 pp.
- Goreau, T. F. 1959. The ecology of Jamaican coral reefs I. Species composition and zonation. *Ecology* 40(1):67-90.
- Goreau, T. F., and J. W. Wells. 1967. The shallow-water *Scleractinia* of Jamaica: Revised list of species and their vertical distribution range. *Bulletin of Marine Science* 17(2):442-453.
- Gorham, J. C., and coauthors. 2014. Characterization of a subtropical hawksbill sea turtle (*Eretmochelys imbricata*) assemblage utilizing shallow water natural and artificial habitats in the Florida Keys. *PLoS One* 9(12):e114171.
- Gower, J. F. R., and S. A. King. 2011. Distribution of floating *Sargassum* in the Gulf of Mexico and the Atlantic Ocean mapped using MERIS. *International Journal of Remote Sensing* 32(7):1917-1929.
- Graham, J. E., and R. van Woesik. 2013. The effects of partial mortality on the fecundity of three common Caribbean corals. *Marine Biology*:1-5.
- Graham, R. T., and coauthors. 2012. Satellite tracking of manta rays highlights challenges to their conservation. *PLoS ONE* 7(5):e36834.

- Greenlee, B., and coauthors. 2017. Assessment of Critical Habitats for Recovering the Chesapeake Bay Atlantic Sturgeon Distinct Population Segment.
- Group, E. S. 2005. Canadian Forces Maritime Experimental and Test Ranges (CFMETR) Environmental Assessment Update 2005 (pp. 652). Kingston, Ontario: Environmental Sciences Group, Royal Military College.
- Group, N. A. L. W. 2018. Northwest Atlantic Leatherback Turtle Status Assessment.
- Gu, B., D. Schell, T. Frazer, M. Hoyer, and F. Chapman. 2001. Stable carbon isotope evidence for reduced feeding of Gulf of Mexico sturgeon during their prolonged river residence period. *Estuarine, Coastal and Shelf Science* 53(3):275-280.
- Gudger, E. W. 1922. The most northerly record of the capture in Atlantic waters of the United States of the giant ray, *Manta birostris*. *Science* 55(1422):338-340.
- Guillen, G. 2003. Klamath River fish die-off, September 2002: causative factors of mortality. US Fish and Wildlife Service, Arcata Fish and Wildlife Office.
- Gulland, F. M., and A. J. Hall. 2007. Is marine mammal health deteriorating? Trends in the global reporting of marine mammal disease. *Ecohealth* 4(2):135-150.
- Hager, C. H., J. C. Watterson, and J. E. Kahn. 2020. Spawning drivers and frequency of endangered Atlantic Sturgeon in the York River system. *Transactions of the American Fisheries Society* 149(4):474-485.
- Hallegraeff, G., and C. Bolch. 1992. Transport of diatom and dinoflagellate resting spores in ships' ballast water: implications for plankton biogeography and aquaculture. *Journal of Plankton Research* 14(8):1067-1084.
- Hallegraeff, G. M. 1998. Transport of toxic dinoflagellates via ships' ballast water: bioeconomic risk assessment and efficacy of possible ballast water management strategies. *Marine Ecology-Progress Series* 168:297-309.
- Halvorsen, M. B., W. T. Ellison, D. R. Choicoine, and A. N. Popper. 2012. Effects of mid-frequency active sonar on hearing in fish. *Journal of the Acoustical Society of America* 131(1):599-607.
- Hamer, J. P., I. Lucas, and T. McCollin. 2001. Harmful dinoflagellate resting cysts in ships' ballast tank sediments: potential for introduction into English and Welsh waters. *Phycologia* 40(3):246-255.
- Hamer, J. P., T. McCollin, and I. Lucas. 2000. Dinoflagellate Cysts in Ballast Tank Sediments: Between Tank Variability. *Marine Pollution Bulletin* 40(9):731-733.
- Hamilton, P. K., A. R. Knowlton, M. K. Marx, and S. D. Kraus. 1998. Age structure and longevity in North Atlantic right whales *Eubalaena glacialis* and their relation to reproduction. *Marine Ecology Progress Series* 171:285-292.
- Hammerschmidt, C. R., M. B. Sandheinrich, J. G. Wiener, and R. G. Rada. 2002. Effects of dietary methylmercury on reproduction of fathead minnows. *Environmental science & technology* 36(5):877-883.
- Hanlon, R. T., and J. B. Messenger. 1996. *Cephalopod Behaviour*. Cambridge University Press, Cambridge, New York.
- Hargrove, S. T., T. Work, S. Brunson, A. M. Foley, and G. Balazs. 2016. Proceedings of the 2015 international summit on fibropapillomatosis: global status, trends, and population impacts. U.S. Department of Commerce, NOAA Technical Memo.
- Harris, C. M., and coauthors. 2019. Changes in the Spatial Distribution of Acoustically Derived Minke Whale (*Balaenoptera acutorostrata*) Tracks in Response to Navy Training. *Aquatic Mammals* 45(6):661-674.

- Harris, C. M., and coauthors. 2015. Dose response severity functions for acoustic disturbance in cetaceans using recurrent event survival analysis. *Ecosphere* 6(11):Article 236.
- Harris, C. M., and coauthors. 2017a. Marine mammals and sonar: dose-response studies, the risk-disturbance hypothesis and the role of exposure context. *Journal of Applied Ecology*:1-9.
- Harris, C. M., L. J. Wilson, C. G. Booth, and J. Harwood. 2017b. Population consequences of disturbance: A decision framework to identify priority populations for PCoD modelling. 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, Canada.
- Harrison, P. L., D. W. dela Cruz, K. A. Cameron, and P. C. Cabaitan. 2021. Increased coral larval supply enhances recruitment for coral and fish habitat restoration. *Frontiers in Marine Science* 8:750210.
- Harry, A., W. Macbeth, A. Gutteridge, and C. Simpfendorfer. 2011. The life histories of endangered hammerhead sharks (Carcharhiniformes, Sphyrnidae) from the east coast of Australia. *Journal of Fish Biology* 78(7):2026-2051.
- Hart, K. M., M. M. Lamont, A. R. Sartain, and I. Fujisaki. 2014. Migration, foraging, and residency patterns for northern gulf loggerheads: Implications of local threats and international movements. *PLoS One* 9(7):e103453.
- Hart, K. M., P. Mooreside, and L. B. Crowder. 2006. Interpreting the spatio-temporal patterns of sea turtle strandings: going with the flow. *Biological Conservation* 129(2):283-290.
- Harvey, P. H., and R. M. May. 1997. Case studies of extinction. *Nature* 385:776-777.
- Haskell, C. A., K. F. Tiffan, and D. W. Rondorf. 2006. Food habits of juvenile American shad and dynamics of zooplankton in the Lower Columbia River. U. S. G. Survey, editor. Western Fisheries Research Center, Columbia River Research Laboratory, Cook, Washington.
- Hastings, M., A. Popper, J. Finneran, and P. Lanford. 1996. Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish *Astronotus ocellatus*. *Journal of the Acoustical Society of America* 99(3):1759-1766.
- Hastings, M. C. 1990. Effects of underwater sound on fish. AT&T Bell Laboratories.
- Hastings, M. C. 1995. Physical effects of noise on fishes. The 1995 International Congress on Noise Control Engineering.
- Hastings, M. C., and A. N. Popper. 2005. Effects of sound on fish. California Department of Transportation, Sacramento, California.
- Hastings, R. W. 1983. A study of the shortnose sturgeon (*Acipenser brevirostrum*) population in the upper tidal Delaware River: assessment of impacts of maintenance dredging.
- Hatch, L. T., C. W. Clark, S. M. V. Parijs, A. S. Frankel, and D. W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a US. National Marine Sanctuary. *Conservation Biology* 26(6):983-994.
- Hatcher, B. G. 1997. Coral reef ecosystems: How much greater is the whole than the sum of the parts? *Coral Reefs* 16:77-91.
- Hatin, D., J. Munro, F. Caron, and R. D. Simons. 2007. Movements, home range size, and habitat use and selection of early juvenile Atlantic sturgeon in the St. Lawrence estuarine transition zone. Pages 129 in American Fisheries Society Symposium. American Fisheries Society.
- Haver, S. M., and coauthors. 2021. Large Vessel Activity and Low-Frequency Underwater Sound Benchmarks in United States Waters. *Frontiers in Marine Science* 8.

- Hawkes, J. P. 2024. Annual report of the US Atlantic Salmon Assessment Committee: report no. 36-2023 activities.
- Hawkins, A. D., C. Johnson, and A. N. Popper. 2020. How to set sound exposure criteria for fishes. *The Journal of Acoustical Society of America* 147(3):1762-1777.
- Hawkins, A. D., and A. D. F. Johnstone. 1978. The hearing of the Atlantic salmon, *Salmo salar*. *Journal of fish biology* 13:655–673.
- Hayes, C. G., Y. Jiao, and E. Cortés. 2009. Stock assessment of scalloped hammerheads in the western North Atlantic Ocean and Gulf of Mexico. *North American Journal of Fisheries Management* 29(5):1406-1417.
- Hayes, S. A., E. Josephson, K. Maze-Foley, and P. E. Rosel. 2017. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2016. National Marine Fisheries Service Northeast Fisheries Science Center, NMFS-NE-241, Woods Hole, Massachusetts.
- Hayes, S. A., E. Josephson, K. Maze-Foley, and P. E. Rosel. 2020. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2019 U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center Woods Hole, Massachusetts.
- Hayes, S. A., E. Josephson, K. Maze-Foley, P. E. Rosel, and J. McCordic. 2024. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2023. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center Woods Hole, Massachusetts.
- Hayes, S. A., and coauthors. 2023. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2022. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center Woods Hole, Massachusetts.
- Hayes, S. A., E. Josephson, K. Maze-Foley, P. E. Rosel, and J. Turek. 2021. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2020. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center Woods Hole, Massachusetts.
- Hayes, S. A., E. Josephson, K. Maze-Foley, P. E. Rosel, and J. Wallace. 2022. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2021. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center Woods Hole, Massachusetts.
- Hays, G. C. 2000. The implications of variable remigration intervals for the assessment of population size in marine turtles. *Journal of Theoretical Biology* 206(2):221-7.
- Hays, G. C., A. D. Mazaris, and G. Schofield. 2014. Different male vs. female breeding periodicity helps mitigate offspring sex ratio skews in sea turtles. *Frontiers in Marine Science* 1:43.
- Hazel, J., I. R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research* 3:105-113.
- Hazin, F., A. Fischer, and M. Broadhurst. 2001. Aspects of reproductive biology of the scalloped hammerhead shark, *Sphyrna lewini*, off northeastern Brazil. *Environmental Biology of Fishes* 61(2):151-159.
- Hedger, R. D., and coauthors. 2009. Migration and swimming depth of Atlantic salmon kelts *Salmo salar* in coastal zone and marine habitats. *Marine Ecology Progress Series* 392:179–192.

- Heinrichs, S., M. O'Malley, H. Medd, and P. Hilton. 2011. Manta ray of hope: global threat to manta and mobula rays. Manta Ray of Hope Project (www.mantarayofhope.com).
- Heise, R., W. Slack, S. T. Ross, and M. Dugo. 2005. Gulf sturgeon summer habitat use and fall migration in the Pascagoula River, Mississippi, USA. *Journal of Applied Ichthyology* 21(6):461-468.
- Heise, R. J., W. T. Slack, S. T. Ross, and M. A. Dugo. 2004. Spawning and associated movement patterns of Gulf sturgeon in the Pascagoula River drainage, Mississippi. *Transactions of the American Fisheries Society* 133(1):221-230.
- Helm, J. E., S. M. Gende, and P. M. Lukacs. 2023. Quantifying behavior and collision risk of humpback whales surfacing near large ships: implications for detection and avoidance. *Endangered Species Research* 51:115-126.
- Henderson, E. E., J. Aschettino, M. Deakos, G. Alongi, and T. Leota. 2019. Quantifying the Behavior of Humpback Whales (*Megaptera novaeangliae*) and Potential Responses to Sonar. *Aquatic Mammals* 45(6):612-631.
- Henderson, E. E., R. Manzano-Roth, C. Martin, and B. Matsuyama. 2015. Impacts of U.S. Navy training events on beaked whale foraging dives in Hawaiian waters: Update. San Diego, CA: SPAWAR Systems Center Pacific.
- Henderson, E. E., S. W. Martin, S. W. Martin, and B. Matsuyama. 2016. Occurrence and habitat use of foraging Blainville's beaked whales (*Mesoplodon densirostris*) on a U.S. Navy range in Hawai'i. *Aquatic Mammals*, 42(4). .
- Henry, A., and coauthors. 2022. Serious injury and mortality determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2016-2020. C. Northeast Fisheries Science, editor. National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts.
- Heppell, S. S., and coauthors. 2005. A population model to estimate recovery time, population size, and management impacts on Kemp's ridley sea turtles. *Chelonian Conservation and Biology* 4(4):767-773.
- Hernandez-Fernandez, L., and coauthors. 2019. Distribution and status of living colonies of *Acropora* spp. in the reef crests of a protected marine area of the Caribbean (Jardines de la Reina National Park, Cuba). *PeerJ* 7:e6470.
- Heublein, J. C., and A. J. Kaeser. 2022. Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) 5-Year Review: Summary and Evaluation.
- Hewitt, R. P. 1985. Reaction of dolphins to a survey vessel: Effects on census data. *Fishery Bulletin* 83(2):187-194.
- Highsmith, R. C. 1982. Reproduction by fragmentation in corals. *Marine Ecology Progress Series* 7(2):207-226.
- Hightower, J. E., M. Loeffler, W. C. Post, and D. L. Peterson. 2015. Estimated survival of subadult and adult Atlantic Sturgeon in four river basins in the southeastern United States. *Marine and Coastal Fisheries* 7(1):514-522.
- Hildebrand, J. 2004. Impacts of anthropogenic sound on cetaceans. Unpublished paper submitted to the International Whaling Commission Scientific Committee SC/56 E 13.
- Hildebrand, J. A. 2005. Impacts of anthropogenic sound. Pages 101-124 in J. E. Reynolds, editor. *Marine mammal research: Conservation beyond crisis*. The John Hopkins University Press.
- Hildebrand, J. A. 2009a. Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series* 395:20-May.

- Hildebrand, J. A. 2009b. Metrics for characterizing the sources of ocean anthropogenic noise. *Journal of the Acoustical Society of America* 125(4):2517.
- Hill, R. L., and Y. Sadovy de Mitcheson. 2013. Nassau Grouper, *Epinephelus striatus* (Bloch 1792), Status Review Document. Report to National Marine Fisheries Service, Southeast Regional Office. .
- Hinojosa-Alvarez, S., R. P. Walter, P. Diaz-Jaimes, F. Galván-Magaña, and E. M. Paig-Tran. 2016. A potential third Manta Ray species near the Yucatán Peninsula? Evidence for a recently diverged and novel genetic Manta group from the Gulf of Mexico. *PeerJ* 4:e2586.
- Hochscheid, S. 2014. Why we mind sea turtles' underwater business: A review on the study of diving behavior. *Journal of Experimental Marine Biology and Ecology* 450:118–136.
- Hodge, K. B., C. A. Muirhead, J. L. Morano, C. W. Clark, and A. N. Rice. 2015. North Atlantic right whale occurrence near wind energy areas along the mid-Atlantic U.S. coast: Implications for management. *Endangered Species Research* 28(3):225-234.
- Holst, M., and coauthors. 2011. Responses of pinnipeds to Navy missile launches at San Nicolas Island, California. *Aquatic Mammals* 37(2):139-150.
- Holt, M. M. 2008. Sound exposure and Southern Resident killer whales (*Orcinus orca*): A review of current knowledge and data gaps. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.
- Holt, M. M., D. P. Noren, R. C. Dunkin, and T. M. Williams. 2015. Vocal performance affects metabolic rate in dolphins: Implications for animals communicating in noisy environments. *Journal of Experimental Biology* 218(11):1647-1654.
- Horn, C., and coauthors. 2022. Endangered species act status review report: Queen conch (*Aliger gigas*).
- Horrocks, J. A., and coauthors. 2001. Migration routes and destination characteristics of post-nesting hawksbill turtles satellite-tracked from Barbados, West Indies. *Chelonian Conservation and Biology* 4(1):107-114.
- Hoss, D. E., and L. R. Settle. 1990. Ingestion of plastics by teleost fishes. National Oceanic and Atmospheric Administration, NFMS-SWFSC-154, Honolulu, HI.
- Hotchkin, C., and S. Parks. 2013. The Lombard effect and other noise-induced vocal modifications: Insight from mammalian communication systems. *Biological Reviews* 88(4):809-824.
- Houser, D. S., and coauthors. 2024. Direct hearing measurements in a baleen whale suggest ultrasonic sensitivity. *Science* 386(6724):902-906.
- Howell, L., and coauthors. 2021. Northern Gulf of Mexico sea turtle strandings: a summary of findings and analyses from 2015-2019. Department of Commerce, National Marine Fisheries Service.
- Howey-Jordan, L. A., and coauthors. 2013. Complex Movements, Philopatry and Expanded Depth Range of a Severely Threatened Pelagic Shark, the Oceanic Whitetip (*Carcharhinus longimanus*) in the Western North Atlantic. *PLoS One* 8(2):e56588.
- Huang, D., and K. Roy. 2013. Anthropogenic extinction threats and future loss of evolutionary history in reef corals. *Ecology and Evolution* 3(5):1184-1193.
- Huff, J. A. 1975. Life history of Gulf of Mexico sturgeon, *Acipenser oxrhynchus desotoi*, in Suwannee River, Florida.
- Hughes, T. P. 1987. Skeletal Density and Growth Form of Corals. *Marine Ecology Progress Series* 35(3):259-266.

- Hughes, T. P., and J. H. Connell. 1999. Multiple stressors on coral reefs: A long-term perspective. *Limnology and Oceanography* 44(3, part 2):932–940.
- Hulin, V., V. Delmas, M. Girondot, M. H. Godfrey, and J.-M. Guillon. 2009. Temperature-dependent sex determination and global change: are some species at greater risk? *Oecologia* 160(3):493–506.
- Hullar, T. L., and coauthors. 1999. Environmental effects of RF chaff: A select panel report to the Undersecretary of Defense for Environmental Security. Naval Research Laboratory, Washington, DC.
- Illingworth and Rodkin Inc. 2001. Noise and vibration measurements associated with the pile installation demonstration project for the San Francisco-Oakland Bay Bridge east span, final data report.
- Illingworth and Rodkin Inc. 2004. Conoco/Phillips 24-inch steel pile installation – Results of underwater sound measurements. Letter to Ray Neal, Conoco/Phillips Company.
- Illingworth, R., and R. Rodkin. 2007. Compendium of pile driving sound data. Prepared for the California Department of Transportation, Sacramento, CA.
- Incardona, J. P., and coauthors. 2015. Very low embryonic crude oil exposures cause lasting cardiac defects in salmon and herring. *Sci Rep* 5:13499.
- Incardona, J. P., and coauthors. 2014. Deepwater Horizon crude oil impacts the developing hearts of large predatory pelagic fish. *Proc Natl Acad Sci U S A* 111(15):E1510–8.
- Ingram, E., and D. Peterson. 2018. Seasonal movements of shortnose sturgeon (*Acipenser brevirostrum*) in the Altamaha River, Georgia. *River research and applications* 34(7):873–882.
- Ingram, E. C., R. M. Cerrato, K. J. Dunton, and M. G. Frisk. 2019. Endangered Atlantic Sturgeon in the New York Wind Energy Area: implications of future development in an offshore wind energy site. *Scientific Reports* 9(1):12432.
- IOTC. 2014. Report of the Seventeenth Session of the IOTC Scientific Committee, IOTC–2014–SC17–R[E].
- IPCC. 2014. Climate change 2014: Impacts, adaptation, and vulnerability. IPCC Working Group II contribution to AR5. Intergovernmental Panel on Climate Change.
- IPCC. 2023. Summary for Policymakers. IPCC, Geneva, Switzerland.
- Ischer, T., K. Ireland, and D. T. Booth. 2009. Locomotion performance of green turtle hatchlings from the Heron Island Rookery, Great Barrier Reef. *Marine Biology* 156(7):1399–1409.
- Isojunno, S., and coauthors. 2016. Sperm whales reduce foraging effort during exposure to 1–2 kHz sonar and killer whale sounds. *Ecological Applications* 26(1):77–93.
- Isojunno, S., and P. J. O. Miller. 2015. Sperm whale response to tag boat presence: Biologically informed hidden state models quantify lost feeding opportunities. *Ecosphere* 6(1):Article 6.
- Isojunno, S., and coauthors. 2020. When the noise goes on: received sound energy predicts sperm whale responses to both intermittent and continuous navy sonar. *Journal of Experiential Biology* 223:15pp.
- Izadi, S., M. Johnson, N. A. de Soto, and R. Constantine. 2018. Night-life of Bryde’s whales: ecological implications of resting in a baleen whale. *Behavioral Ecology and Sociobiology* 72:1–12.
- Jaap, W. C. 1984. The ecology of the south Florida coral reefs: A community profile. Minerals Management Service, Outer Continental Shelf Regional Office, National Coastal Ecosystems Team and Gulf of Mexico.

- Jaap, W. C., W. G. Lyons, P. Dustan, and J. C. Halas. 1989. Stony coral (Scleractinia and Milleporina) community structure at Bird Key Reef, Ft. Jefferson National Monument, Dry Tortugas, Florida.
- Jackson, G. D., N. G. Buxton, and M. J. A. George. 2000. Diet of the southern opah, *Lampris immaculatus*, on the Patagonian Shelf; the significance of the squid, *Moroteuthis ingens*, and anthropogenic plastic. Marine Ecology Progress Series 206:261–271.
- Jackson, J. B. C., M. K. Donovan, K. L. Cramer, and V. V. Lam. 2014. Status and Trends of Caribbean Coral Reefs: 1970-2012. Global Coral Reef Monitoring Network, IUCN, Gland, Switzerland.
- Jacobsen, J. K., L. Massey, and F. Gulland. 2010. Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). Marine Pollution Bulletin 60(5):765-767.
- Jambeck, J. R., and coauthors. 2015. Plastic waste inputs from land into the ocean. Science 347(6223):768-771.
- James, M. C., R. A. Myers, and C. A. Ottensmeyer. 2005. Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. Proceedings of the Royal Society Biological Sciences Series B 272(1572):1547-1555.
- Jauniaux, T., and coauthors. 2000. Pathological findings in two fin whales (*Balaenoptera physalus*) with evidence of morbillivirus infection. Journal of comparative pathology 123(2-3):198-201.
- Jay, A., and coauthors. 2018. In: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA:33-71.
- Jenkins, A. K., and coauthors. 2022. Physical effects of sound exposure from underwater explosions on Pacific mackerel (*Scomber japonicus*): Effects on non-auditory tissues. The Journal of Acoustical Society of America 151(6):3947-3956.
- Jenkins, A. K., and coauthors. 2023. Physical Effects from Underwater Explosions on Two Fish Species. Pages 1-9 in *The Effects of Noise on Aquatic Life: Principles and Practical Considerations*. Springer.
- Jenkins, W. E., T. I. J. Smith, L. D. Heyward, and D. M. Knott. 1993. Tolerance of shortnose sturgeon, *Acipenser brevirostrum*, juveniles to different salinity and dissolved oxygen concentrations. Pages 476-484 in *Annual Conference of the Southeastern Association of Fish and Wildlife Agencies*.
- Jensen, A. S., and G. K. Silber. 2003. Large whale ship strike database. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/OPR-25.
- Jochens, A. E., and coauthors. 2006. Sperm whale seismic study in the Gulf of Mexico; Summary report 2002-2004. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, OCS Study MMS 2006-034, New Orleans, Louisiana.
- Johnson, G. C., J. M. Lyman, G. C. Johnson, and J. M. Lyman. 2020. Warming trends increasingly dominate global ocean. Nature Climate Change 2020 10:8 10(8).
- Johnson, H., D. Morrison, and C. Taggart. 2021. WhaleMap: a tool to collate and display whale survey results in near real-time. Journal of Open Source Software 6(62):3094.
- Johnson, O. H., and coauthors. 2025. Suitability of foraging habitat for *Eubalaena glacialis* under future climate scenarios in the Northwest Atlantic. Elem Sci Anth 13(1):00044.

- Johnston, C. E., and C. T. Phillips. 2003. Sound production in sturgeon *Scaphirhynchus albus* and *S. platyrhynchus* (Acipenseridae). *Environmental Biology of Fishes* 68(1):59-64.
- Jones, K., E. Ariel, G. Burgess, and M. Read. 2015. A review of fibropapillomatosis in green turtles (*Chelonia mydas*). *The Veterinary Journal* 212:48-57.
- Jørgensen, R., N. O. Handegard, H. Gjøsæter, and A. Slotte. 2004. Possible vessel avoidance behaviour of capelin in a feeding area and on a spawning ground. *Fisheries Research* 69(2):251–261.
- Jorgensen, R., K. Olsen, I. Petersen, and P. Kanapthipplai. 2005. Investigations of potential effects of low frequency sonar signals on survival, development and behaviour of fish larvae and juveniles. University of Tromso, The Norwegian College of Fishery Science.
- Jorgensen, S., A. Klimley, and A. Muhlia-Melo. 2009. Scalloped hammerhead shark *Sphyrna lewini*, utilizes deep-water, hypoxic zone in the Gulf of California. *Journal of Fish Biology* 74(7):1682-1687.
- Jossey, S., and coauthors. 2024. Population structure and history of North Atlantic Blue whales (*Balaenoptera musculus musculus*) inferred from whole genome sequence analysis. *Conservation Genetics* 25(2):357-371.
- Joung, S.-J., N.-F. Chen, H.-H. Hsu, and K.-M. Liu. 2016. Estimates of life history parameters of the oceanic whitetip shark, *Carcharhinus longimanus*, in the Western North Pacific Ocean. *Marine Biology Research* 12(7):758-768.
- Juutilainen, J. 2005. Developmental effects of electromagnetic fields. *Bioelectromagnetics* 26(S7):S107-S115.
- Kabay, L. 2016. Population Demographics and Sexual Reproduction Potential of the Pillar Coral, *Dendrogyra cylindrus*, on the Florida Reef Tract. Masters. Nova Southeastern University, Ft. Lauderdale, FL.
- Kahn, J., C. Hager, J. Watterson, N. Mathies, and K. Hartman. 2019. Comparing abundance estimates from closed population mark-recapture models of endangered adult Atlantic sturgeon. *Endangered Species Research* 39:63-76.
- Kahn, J., J. Watterson, C. Hager, N. Mathies, and K. Hartman. 2021. Calculating adult sex ratios from observed breeding sex ratios for wide-ranging, intermittently breeding species. *Ecosphere* 12(5):e03504.
- Kahn, J. E. 2019. Adult Atlantic sturgeon population dynamics in the York River, Virginia. West Virginia University.
- Kahn, J. E., and coauthors. 2023. Population and sex-specific survival estimates for Atlantic sturgeon: addressing detection probability and tag loss. *Aquatic Biology* 32:1-12.
- Kahn, J. E., and coauthors. 2014. Atlantic sturgeon annual spawning run estimate in the Pamunkey River, Virginia. *Transactions of the American Fisheries Society* 143(6):1508-1514.
- Kahnle, A. W., K. A. Hattala, and K. A. Mckown. 2007. Status of Atlantic sturgeon of the Hudson River Estuary, New York, USA. *American Fisheries Society Symposium* 56:347-363.
- Kahnle, A. W., and coauthors. 1998. Atlantic Sturgeon Stock Assessment: Peer Review Report. Atlantic States Marine Fisheries Commission, Washington, D.C. .
- Kane, A. S., and coauthors. 2010. Exposure of fish to high-intensity sonar does not induce acute pathology. *Journal of Fish Biology* 76(7):1825-1840.

- Karl, S. A., B. W. Bowen, and J. C. Avise. 1992. Global population genetic structure and male-mediated gene flow in the green turtle (*Chelonia mydas*): RFLP analyses of anonymous nuclear loci. *Genetics* 131(1):163-173.
- Kashiwagi, T., T. Ito, and F. Sato. 2010. Occurrences of reef manta ray, *Manta alfredi*, and giant manta ray, *M. birostris*. Japan, examined by photographic records. *Report of Japanese Society for Elasmobranch Studies* 46:20-27.
- Kashiwagi, T., A. D. Marshall, M. B. Bennett, and J. R. Ovenden. 2011. Habitat segregation and mosaic sympatry of the two species of manta ray in the Indian and Pacific Oceans: *Manta alfredi* and *M. birostris*. *Marine Biodiversity Records* 4.
- Kastak, D., J. Mulsow, A. Ghoul, and C. Reichmuth. 2008. Noise-induced permanent threshold shift in a harbor seal. *Journal of the Acoustical Society of America* 123(5 Part 2):2986.
- Kastelein, R. A., R. Gransier, L. Hoek, A. Macleod, and J. M. Terhune. 2012. Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. *The Journal of Acoustical Society of America* 132(4):2745–61.
- Kastelein, R. A., L. Helder-Hoek, S. Cornelisse, L. A. Huijser, and R. Gransier. 2019. Temporary hearing threshold shift in harbor porpoises (*Phocoena phocoena*) due to one-sixth-octave noise band at 32 kHz. *Aquatic Mammals* 45(5):549-562.
- Kazyak, D. C., and coauthors. 2020. Integrating side-scan sonar and acoustic telemetry to estimate the annual spawning run size of Atlantic sturgeon in the Hudson River. *Canadian Journal of Fisheries and Aquatic Sciences* 77(6):1038-1048.
- Kazyak, D. C., S. L. White, B. A. Lubinski, R. Johnson, and M. Eackles. 2021. Stock composition of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) encountered in marine and estuarine environments on the U.S. Atlantic Coast. *Conservation Genetics* 22(5):767-781.
- Keen, K. A., R. S. Beltran, E. Pirotta, and D. P. Costa. 2021. Emerging themes in population consequences of disturbance models. *Proceedings of the Royal Society B* 288(1957):20210325.
- Keller, J. M., and coauthors. 2005. Perfluorinated compounds in the plasma of loggerhead and Kemp's ridley sea turtles from the southeastern coast of the United States. *Environmental Science and Technology* 39(23):9101-9108.
- Keller, J. M., J. R. Kucklick, M. A. Stamper, C. A. Harms, and P. D. McClellan-Green. 2004. Associations between organochlorine contaminant concentrations and clinical health parameters in loggerhead sea turtles from North Carolina, USA. *Environmental Health Perspectives* 112(10):1074.
- Keller, J. M., P. D. McClellan-Green, J. R. Kucklick, D. E. Keil, and M. M. Peden-Adams. 2006. Effects of organochlorine contaminants on loggerhead sea turtle immunity: Comparison of a correlative field study and *in vitro* exposure experiments. *Environmental Health Perspectives* 114(1):70-76.
- Kelley, C., G. Carton, M. Tomlinson, and A. Gleason. 2016. Analysis of towed camera images to determine the effects of disposed mustard-filled bombs on the deep water benthic community off south Oahu. *Deep Sea Research Part II: Topical Studies in Oceanography*.
- Kelley, D. E., J. P. Vlasic, and S. W. Brilliant. 2021. Assessing the lethality of ship strikes on whales using simple biophysical models. *Marine Mammal Science* 37(1):251-267.
- Kendall, J. 2010. Aerial Surveying of Wild Manta Ray Populations. *National Geographic Inside Wild*.

- Kenney, R. D. 2009. Right whales: *Eubalaena glacialis*, *E. japonica*, and *E. australis*. Pages 962-972 in W. F. Perrin, B. Würsig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals, Second edition. Academic Press, San Diego, California.
- Ketten, D. R. 1992. The cetacean ear: Form, frequency, and evolution. Pages 53-75 in R. A. Kastelein, A. Y. Supin, and J. A. Thomas, editors. Marine Mammal Sensory Systems. Plenum Press, New York.
- Ketten, D. R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. Pages 391-407 in R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall, editors. Sensory Systems of Aquatic Mammals. De Spil Publishers, Woerden.
- Ketten, D. R. 1997. Structure and function in whale ears. Bioacoustics 8:103-135.
- Ketten, D. R. 1998. Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and its Implications for Underwater Acoustic Impacts. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-256.
- Ketten, D. R., J. Lien, and S. Todd. 1993. Blast injury in humpback whale ears: Evidence and implications. Journal of the Acoustical Society of America 94(3 Part 2):1849-1850.
- Kiessling, I. 2003. Finding solutions: derelict fishing gear and other marine debris in northern Australia. National Oceans Office.
- Kincaid, A.L., J.A. Lasala, J.L. Blackburn, B.A. Stacy, and G.N. Lovewell. (in press). Analysis of Anatomical Location and Severity of Watercraft Injuries in Different Species of Sea Turtles. Endangered Species Research.
- King, S. L., and coauthors. 2015. An interim framework for assessing the population consequences of disturbance. Methods in Ecology and Evolution 6(10):1150–1158.
- King, T. L., B. A. Lubinski, and A. P. Spidle. 2001. Microsatellite DNA variation in Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and cross-species amplification in the Acipenseridae. Conservation Genetics 2(2):103-119.
- Kintisch, E. 2006. As the seas warm: Researchers have a long way to go before they can pinpoint climate-change effects on oceangoing species. Science 313:776-779.
- Kipple, B., and C. Gabriele. 2004. Underwater noise from skiffs to ships. S. M. J. F. G. Piatt, editor Fourth Glacier Bay Science Symposium.
- Kirschvink, J. L. 1990. Geomagnetic sensitivity in cetaceans: An update with live stranding records in the United States. Pages 639-649 in R. A. J. A. K. Thomas, editor. Sensory Abilities of Cetaceans: Laboratory and Field Evidence.
- Kirschvink, J. L. 1997. Homing in on vertebrates. Nature 390(6658):339-340.
- Kiszka, J. J., and coauthors. 2023. Critically endangered Rice's whales (*Balaenoptera ricei*) selectively feed on high-quality prey in the Gulf of Mexico. Scientific Reports 13(1):6710.
- Kitchen-Wheeler, A.-M. 2013. The behaviour and ecology of Alfred mantas (*Manta alfredi*) in the Maldives. Newcastle University.
- Klimley, A. 1993. Highly directional swimming by scalloped hammerhead sharks, *Sphyrna lewini*, and subsurface irradiance, temperature, bathymetry, and geomagnetic field. Marine Biology 117(1):1-22.
- Klimley, A. P., and D. R. Nelson. 1981. Schooling of the scalloped hammerhead shark, *Sphyrna lewini*, in the Gulf of California. Fishery Bulletin 79(2):356–360.
- Klinowska, M. 1985. Cetacean live stranding dates relate to geomagnetic disturbances. Aquatic Mammals 11(3):109-119.

- Klinowska, M. 1990. Geomagnetic orientation in cetaceans: Behavioural evidence. Pages 651-663 in J. A. T. R. A. Kastelein, editor. *Sensory Abilities of Cetaceans: Laboratory and Field Evidence*. Plenum Press, New York.
- Knowlton, A. R., P. K. Hamilton, M. K. Marx, H. M. Pettis, and S. D. Kraus. 2012. Monitoring North Atlantic right whale *Eubalaena glacialis* entanglement rates: a 30 yr retrospective. *Marine Ecology Progress Series* 466:293-302.
- Knowlton, A. R., F. T. Korsmeyer, J. E. Kerwin, H. Wu, and B. Hynes. 1995. The hydrodynamic effects of large vessels on right whales. Pages 62 in *Eleventh Biennial Conference on the Biology of Marine Mammals*, Orlando, Florida.
- Knowlton, A. R., and S. D. Kraus. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *Journal of Cetacean Research and Management Special Issue* 2:193-208.
- Knowlton, A. R., S. D. Kraus, and R. D. Kenney. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). *Canadian Journal of Zoology* 72(7):1297-1305.
- Knowlton, N., J. L. Maté, H. M. Guzmán, R. Rowan, and J. Jara. 1997. Direct evidence for reproductive isolation among the three species of the *Montastraea annularis* complex in Central America (Panamá and Honduras). *Marine Biology* 127(4):705-711.
- Kocan, R., M. Matta, and S. Salazar. 1993. A laboratory evaluation of Connecticut River coal tar toxicity to shortnose sturgeon (*Acipenser brevirostrum*) embryos and larvae. Final Report to the National Oceanic and Atmospheric Administration, Seattle, Washington.
- Koch, V., H. Peckham, A. Mancini, and T. Eguchi. 2013. Estimating at-sea mortality of marine turtles from stranding frequencies and drifter experiments. *PLoS One* 8(2):e56776.
- Kocik, J., C. A. Lipsky, T. J. Miller, P. J. Rago, and G. R. Shepherd. 2013. An Atlantic Sturgeon population index for ESA management analysis.
- Koide, S., J. Silva, V. Dupra, and M. Edwards. 2016. Bioaccumulation of chemical warfare agents, energetic materials, and metals in deep-sea shrimp from discarded military munitions sites off Pearl Harbor. *Deep Sea Research Part II: Topical Studies in Oceanography*, 128, 53–62. .
- Kok, A. C., and coauthors. 2023. Kinematics and energetics of foraging behavior in Rice's whales of the Gulf of Mexico. *Scientific Reports* 13(1):8996.
- Koopman, H. N. 2007. Phylogenetic, ecological, and ontogenetic factors influencing the biochemical structure of the blubber of odontocetes. *Marine Biology* 151(1):277-291.
- Koski, W. R., J. W. Lawson, D. H. Thomson, and W. J. Richardson. 1998. Point Mugu Sea Range marine mammal technical report. Naval Air Warfare Center, Weapons Division and Southwest Division, Naval Facilities Engineering Command.
- Kraus, S. D., R. M. Pace, and T. R. Frasier. 2007. High investment, low return: The strange case of reproduction in *Eubalaena glacialis*. Pages 172-199 in S. D. Kraus, and R. M. Rolland, editors. *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, Massachusetts.
- Kraus, S. D., and R. M. Rolland. 2007. Right whales in the urban ocean. Pages Jan-38 in S. D. Kraus, and R. M. Rolland, editors. *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge.
- Kroetz, A. M., and coauthors. 2025. Age, growth, maturity, and natural mortality of the smalltooth sawfish (*Pristis pectinata*) in Florida waters. *Fishery Bulletin* 123:190-206.
- Kufeld, W. G. B., and R. M. 2005. UH-60A airloads catalog. National Aeronautics and Space Administration.

- Kühn, S., E. L. Bravo Rebolledo, and J. A. Van Franeker. 2015. Deleterious effects of litter on marine life. *Marine anthropogenic litter*:75-116.
- Kujawa, S. G., and M. C. Liberman. 2009. Adding insult to injury: Cochlear nerve degeneration after temporary noise-induced hearing loss. *Journal of Neuroscience* 29(14-Feb):14077-85.
- Kunc, H. P., K. E. McLaughlin, and R. Schmidt. 2016. Aquatic noise pollution: implications for individuals, populations, and ecosystems. *Proc Biol Sci* 283(1836).
- Kvadsheim, P. H., and E. M. Sevaldsen. 2005. The potential impact of 1-8 kHz active sonar on stocks of juvenile fish during sonar exercises. *Forsvarets Forskningsinstitut*.
- Kynard, B., and E. Parker. 2004. Ontogenetic behavior and migration of Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*, with notes on body color and development. *Environmental Biology of Fishes* 70(1):43-55.
- LaBrecque, E., C. Curtice, J. Harrison, S. M. Van Parijs, and P. N. Halpin. 2015. Biologically Important Areas for Cetaceans Within U.S. Waters—East Coast Region. *Aquatic Mammals* 41(1):17-29.
- Ladich, F., and R. R. Fay. 2013. Auditory evoked potential audiometry in fish. 23(3):317-364.
- Lagueux, K. M., M. A. Zani, A. R. Knowlton, and S. D. Kraus. 2011. Response by vessel operators to protection measures for right whales *Eubalaena glacialis* in the southeast US calving ground. *Endangered Species Research* 14(1):69-77.
- Laist, D. W. 1997. Impacts of marine debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. Pages 99-140 in D. B. J. M. R. Coe, editor. *Marine Debris: Sources, Impacts, and Solutions*. Springer-Verlag, New York, New York.
- Laist, D. W. 2017. North Atlantic right whales: From hunted Leviathan to conservation icon. JHU Press.
- Laist, D. W., J. M. Coe, and K. J. O'hara. 1999. Marine debris pollution. Pages 342-366 in J. R. R. R. T. Jr., editor. *Conservation and Management of Marine Mammals*. Smithsonian Institution Press, Washington, D. C.
- Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podesta. 2001. Collisions between ships and whales. *Marine Mammal Science* 17(1):35-75.
- Laloë, J. O., G. Schofield, and G. C. Hays. 2024. Climate warming and sea turtle sex ratios across the globe. *Global Change Biology* 30(1):e17004.
- Lambertsen, R. 1992. Crassicaudosis: a parasitic disease threatening the health and population recovery of large baleen whales. *REVUE SCIENTIFIQUE ET TECHNIQUE-OFFICE INTERNATIONAL DES EPIZOOTIES* 11:1131-1131.
- Lamont, M. M., and C. Houser. 2014. Spatial distribution of loggerhead turtle (*Caretta caretta*) emergences along a highly dynamic beach in the northern Gulf of Mexico. *Journal of Experimental Marine Biology and Ecology* 453:98-107.
- Laney, H., and R. C. Cavanagh. 2000. Supersonic aircraft noise at and beneath the ocean surface: Estimation of risk for effects on marine mammals. United States Air Force Research Laboratory.
- Langan, J., G. Puggioni, C. Oviatt, M. Henderson, and J. Collie. 2021. Climate alters the migration phenology of coastal marine species. *Marine Ecology Progress Series* 660:1-18.

- Langan, R. 2004. Balancing marine aquaculture inputs and extraction: combined culture of finfish and bivalve molluscs in the open ocean. BULLETIN-FISHERIES RESEARCH AGENCY JAPAN:51-58.
- Laplanche, C., O. Adam, M. Lopatka, and J. F. Motsch. 2005. Sperm whales click focussing: Towards an understanding of single sperm whale foraging strategies. Pages 56 in Nineteenth Annual Conference of the European Cetacean Society, La Rochelle, France.
- Lari, E., A. Kasumyan, F. Falahat, K. Døving, and V. Jafari. 2013. Palatability of food animals for stellate sturgeon *A. c. stellatus* Pallas, 1771. Journal of Applied Ichthyology 29(6):1222-1224.
- Larson, E. A., D. S. Gilliam, M. López Padierna, and B. K. Walker. 2014. Possible recovery of *Acropora palmata* (Scleractinia:Acroporidae) within the Veracruz Reef System, Gulf of Mexico: a survey of 24 reefs to assess the benthic communities. Revista Biología Tropical 62:75-84.
- Lasala, J. A., and coauthors. 2023. Forty years of monitoring increasing sea turtle relative abundance in the Gulf of Mexico. Scientific Reports 13(1):17213.
- Laughlin, J. 2006. Underwater sound levels associated with pile driving at the Cape Dissappointment boat launch facility, wave barrier project. Washington State Parks Wave Barrier Project Underwater Technical Report.
- Laurent, A., K. Fennel, D. S. Ko, and J. Lehrter. 2018. Climate Change Projected to Exacerbate Impacts of Coastal Eutrophication in the Northern Gulf of Mexico. Journal of Geophysical Research: Oceans 123(5).
- Lavender, A. L., S. M. Bartol, and I. K. Bartol. 2014. Ontogenetic investigation of underwater hearing capabilities in loggerhead sea turtles (*Caretta caretta*) using a dual testing approach. Journal of Experimental Biology 217(14):2580-2589.
- Lawson, J. M., and coauthors. 2017. Sympathy for the devil: a conservation strategy for devil and manta rays. PeerJ 5:e3027.
- Learmonth, J. A., and coauthors. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: an Annual Review 44:431-464.
- Leatherwood, S., F. T. Awbrey, and J. A. Thomas. 1982. Minke whale response to a transiting survey vessel. Report of the International Whaling Commission 32:795-802.
- Lecchini, D., and coauthors. 2018. Boat noise prevents soundscape-based habitat selection by coral planulae. Scientific Reports 8(1):9283.
- Lee, T. N., and coauthors. 1992. Influence of Florida Current, gyres and wind-driven circulation on transport of larvae and recruitment in the Florida Keys coral reefs. Continental Shelf Research 12(7/8):971-1002.
- Leiter, S., and coauthors. 2017. North Atlantic right whale *Eubalaena glacialis* occurrence in offshore wind energy areas near Massachusetts and Rhode Island, USA. Endangered Species Research 34:45-59.
- Lenhardt, M. L. 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). Pages 238-241 in K. A. C. Bjorndal, A. B. C. Bolten, D. A. C. Johnson, and P. J. C. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.
- Lenhardt, M. L. 2002. Sea turtle auditory behavior. Journal of the Acoustical Society of America 112(5 Part 2):2314.

- Leroux, R. A., and coauthors. 2012. Re-examination of population structure and phylogeography of hawksbill turtles in the wider Caribbean using longer mtDNA sequences. *Journal of Heredity* 103(6):806-820.
- Lessa, R., F. M. Santana, and R. Paglerani. 1999. Age, growth and stock structure of the oceanic whitetip shark, *Carcharhinus longimanus*, from the southwestern equatorial Atlantic. *Fisheries Research* 42(1-2):21-30.
- Lester, S. E., R. R. Gentry, and H. E. Froehlich. 2024. The role of marine aquaculture in contributing to the diversity and stability of US seafood production. *Marine Policy* 160:105994.
- Lestrade, O. L., and F. Hernandez. 2023. Microdebris Abundance, Distribution, and Ingestion by Sargassum-Associated Juvenile Fishes in the Gulf of Mexico. *Gulf and Caribbean Research* 34(1):18-28.
- Lettrich, M. D., and coauthors. 2023. Vulnerability to climate change of United States marine mammal stocks in the western North Atlantic, Gulf of Mexico, and Caribbean. *PLoS ONE* 18(9):e0290643.
- Leung, S. K., and P. J. Mumby. 2024. Mapping the susceptibility of reefs to rubble accumulation across the Great Barrier Reef. *Environmental Monitoring and Assessment* 196(2):211.
- Lewis, J. A. 1997. Effects of underwater explosions on life in the sea.
- Liboff, A. 2016. Is the geomagnetic map imprinted in pre-emergent egg? *Electromagnetic biology and medicine* 35(2):167-169.
- Liboff, A. R. 2014. Why are living things sensitive to weak magnetic fields? *Electromagnetic biology and medicine* 33(3):241-245.
- Lighty, R. G., I. G. Macintyre, and R. Stuckenrath. 1982. *Acropora palmata* reef framework: A reliable indicator of sea level in the western atlantic for the past 10,000 years. *Coral Reefs* 1(2):125-130.
- Lilly, E. L., D. M. Kulis, P. Gentien, and D. M. Anderson. 2002. Paralytic shellfish poisoning toxins in France linked to a human-introduced strain of *Alexandrium catenella* from the western Pacific: evidence from DNA and toxin analysis. *Journal of Plankton Research* 24(5):443-452.
- Lin, H. W., A. C. Furman, S. G. Kujawa, and M. C. Liberman. 2011. Primary neural degeneration in the guinea pig cochlea after reversible noise-induced threshold shift. *Journal of the Association for Research in Otolaryngology* 12(605-616).
- Linden, D. 2024a. Population size estimation of North Atlantic right whales from 1990-2023.
- Linden, D. 2024b. Using known births to account for delayed marking in population estimation of North Atlantic right whales.
- Lirman, D. 2000. Fragmentation in the branching coral *Acropora palmata* (Lamarck): Growth, survivorship, and reproduction of colonies and fragments. *Journal of Experimental Marine Biology and Ecology* 251(1):41-57.
- Lirman, D., and coauthors. 2010. A window to the past: documenting the status of one of the last remaining 'megapopulations' of the threatened staghorn coral *Acropora cervicornis* in the Dominican Republic. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20(7):773-781.
- Liu, K.-M., and C.-T. Chen. 1999. Demographic analysis of the scalloped hammerhead, *Sphyrna lewini*, in the northwestern Pacific. *Fisheries science* 65(2):218-223.

- Liu, Y., R. H. Weisberg, L. Zheng, C. A. Heil, and K. A. Hubbard. 2022. Termination of the 2018 Florida red tide event: A tracer model perspective. *Estuarine, Coastal and Shelf Science* 272:107901.
- Lizewski, K., and coauthors. 2025. Change in matrilineal structure over time in an isolated population of sperm whales. *Marine Ecology Progress Series* 758:161-178.
- Lloyd, B. D. 2003. Potential effects of mussel farming on New Zealand's marine mammals and seabirds: A discussion paper. Department of Conservation.
- Lockyer, C. 1984. Review of baleen whale (Mysticeti) reproduction and implications for management. Report of the International Whaling Commission Special Issue 6:27-50.
- Lohmann, K. J., S. D. Cain, S. Dodge, and C. M. F. Lohmann. 2000. Magnetic navigation in hatchling loggerheads. Pages 6 in H. J. Kalb, and T. Wibbels, editors. Nineteenth Annual Symposium on Sea Turtle Biology and Conservation.
- Lohmann, K. J., and C. M. Lohmann. 1996. Detection of magnetic field intensity by sea turtles. *Nature* 380(6569):59.
- Lohmann, K. J., and C. M. Lohmann. 1998. Sea turtle navigation and the detection of geomagnetic field features. *The Journal of Navigation* 51(1):10-22.
- Lotufo, G. R., and coauthors. 2017. Review and Synthesis of Evidence Regarding Environmental Risks Posed by Munitions Constituents (MC) in Aquatic Systems. U.S. Army Corps of Engineers, Engineer Research and Development Center.
- Lotufo, G. R., A. B. Gibson, and J. L. Yoo. 2010. Toxicity and bioconcentration evaluation of RDX and HMX using sheepshead minnows in water exposures. *Ecotoxicology and Environmental Safety* 73(7):1653-1657.
- Lovell, J. M., M. M. Findlay, R. M. Moate, J. R. Nedwell, and M. A. Pegg. 2005. The inner ear morphology and hearing abilities of the paddlefish (*Polyodon spathula*) and the lake sturgeon (*Acipenser fulvescens*). *Comparative Biochemistry and Physiology. Part A, Molecular and Integrative Physiology* 142(3):286-296.
- Lubchenco, J., and N. Sutley. 2010. Proposed U.S. policy for ocean, coast, and great lakes stewardship. *Science* 328:2.
- Luksenburg, J. A., and E. C. Parsons. 2009. The effects of aircraft on cetaceans: Implications for aerial whalewatching.
- Lutcavage, M. E., P. Plotkin, B. E. Witherington, and P. L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 in P. L. L. J. A. Musick, editor. *The Biology of Sea Turtles*. CRC Press, New York, New York.
- Lyons, K., and D. H. Adams. 2015. Maternal offloading of organochlorine contaminants in the yolk-sac placental scalloped hammerhead shark (*Sphyrna lewini*). *Ecotoxicology* 24:553-562.
- Lyons, M. P., B. von Holle, M. A. Caffrey, and J. F. Weishampel. 2020. Quantifying the impacts of future sea level rise on nesting sea turtles in the southeastern United States. *Ecological Applications* 30(5):e02100.
- Lyrholm, T., and U. Gyllensten. 1998. Global matrilineal population structure in sperm whales as indicated by mitochondrial DNA sequences. *Proceedings of the Royal Society B-Biological Sciences* 265(1406):1679-1684.
- Macfadyen, G., T. Huntington, and R. Cappell. 2009. Abandoned, lost or otherwise discarded fishing gear. Food and Agriculture Organization of the United Nations (FAO).

- Macleod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. *Endangered Species Research* 7(2):125-136.
- MacLeod, C. D., and coauthors. 2005. Climate change and the cetacean community of north-west Scotland. *Biological Conservation* 124(4):477-483.
- MacPherson, S. L., and coauthors. 2012. Sea turtle nest translocation effort in the Florida panhandle and Alabama, USA, in response to the *Deepwater Horizon* (MC-252) oil spill in the Gulf of Mexico. Pages 15 in T. T. Jones, and B. P. Wallace, editors. *Thirty-First Annual Symposium on Sea Turtle Biology and Conservation*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, San Diego, California.
- Madhusudhana, S., K. D. Seger, and H. Klinck. 2024. Descriptor: U.S. Navy's Full Ship Shock Trial of 2021 (FSST2021). *IEEE Data Descriptions* 1:66-70.
- Madsen, P. T., and coauthors. 2003. Sound production in neonate sperm whales. *Journal of the Acoustical Society of America* 113(6):2988-2991.
- Madsen, P. T., and coauthors. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *The Journal of Acoustical Society of America* 120(4):2366-2379.
- Magalhaes, S., and coauthors. 2002. Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. *Aquatic Mammals* 28(3):267-274.
- Maguire, J.-J. 2006. The state of world highly migratory, straddling and other high seas fishery resources and associated species. Food & Agriculture Org.
- Malik, S., and coauthors. 1999. Assessment of mitochondrial DNA structuring and nursery use in the North Atlantic right whale (*Eubalaena glacialis*). *Canadian Journal of Zoology* 77(8):1217-1222.
- Malik, S., M. W. Brown, S. D. Kraus, and B. N. White. 2000. Analysis of mitochondrial DNA diversity within and between north and south Atlantic right whales. *Marine Mammal Science* 16(3):545-558.
- Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modelling. Bolt Beranek, & Newman, Inc, Anchorage, AK.
- Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. Pages 55-73 in W. M. Sackinger, M. O. Jeffries, J. L. Imm, and S. D. Tracey, editors. *Port and Ocean Engineering Under Arctic Conditions*, volume 2. Geophysical Institute, University of Alaska, Fairbanks, AK.
- Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: A literature synthesis. U.S. Fish and Wildlife Service, National Ecology Research Center, Ft. Collins, Colorado.
- Mancini, A., V. Koch, J. A. Seminoff, and B. Madon. 2012. Small-scale gill-net fisheries cause massive green turtle *Chelonia mydas* mortality in Baja California Sur, Mexico. *Oryx* 46(1):69-77.
- Mancini, A., and coauthors. 2011. To poach or not to poach an endangered species: Elucidating the economic and social drivers behind illegal sea turtle hunting in Baja California Sur, Mexico. *Human Ecology* 39(6):743-756.

- Mangold, M. S., M. Eyler, and S. Minkinen. 2007. Atlantic sturgeon reward program for Maryland waters of the Chesapeake Bay and tributaries 1996-2006. U.S. Fish and Wildlife Service, Maryland Fishery Resources Office, Annapolis, Maryland.
- Manzano-Roth, R., E. E. Henderson, S. W. Martin, C. Martin, and B. Matsuyama. 2016. Impacts of U.S. Navy Training Events on Blainville's Beaked Whale (*Mesoplodon densirostris*) Foraging Dives in Hawaiian Waters. *Aquatic Mammals*, 42(4), 507–518. .
- Marhaver, K. L., M. J. A. Vermeij, and M. M. Medina. 2015. Reproductive natural history and successful juvenile propagation of the threatened Caribbean Pillar Coral *Dendrogyra cylindrus*. *BMC Ecology* 15:9.
- Marques, T. A., and coauthors. 2023. Population consequences of the Deepwater Horizon oil spill on pelagic cetaceans. *Marine Ecology Progress Series* 714:1-14.
- Marsh, R., and coauthors. 2023. Climate-sargassum interactions across scales in the tropical Atlantic. *PLOS Climate* 2(7):e0000253.
- Marshall, A., and M. Bennett. 2010. Reproductive ecology of the reef manta ray *Manta alfredi* in southern Mozambique. *Journal of Fish Biology* 77(1):169-190.
- Marshall, A., and coauthors. 2016. *Manta birostris*. The IUCN Red List of Threatened Species 2011: e. T198921A9108067.
- Marshall, A. D., L. J. Compagno, and M. B. Bennett. 2009. Redescription of the genus *Manta* with resurrection of *Manta alfredi* (Kreffft, 1868)(Chondrichthyes; Myliobatoidei; Mobulidae). *Zootaxa* 2301(1):1-28.
- Marshall, A. D., C. L. Dudgeon, and M. B. Bennett. 2011. Size and structure of a photographically identified population of manta rays *Manta alfredi* in southern Mozambique. *Marine Biology* 158(5):1111-1124.
- Martin, K. J., and coauthors. 2012. Underwater hearing in the loggerhead turtle (*Caretta caretta*): A comparison of behavioral and auditory evoked potential audiograms. *The Journal of Experimental Biology* 215(17):3001-3009.
- Martin, S. W., C. R. Martin, B. M. Matsuyama, and E. E. Henderson. 2015. Minke whales (*Balaenoptera acutorostrata*) respond to navy training. *Journal of the Acoustical Society of America* 137(5):2533-2541.
- Marvel, K., and coauthors. 2023. Climate trends. A. R. Crimmins, and coeditors, editors. Fifth National Climate Assessment. U.S. Global Change Research Program, Washington, DC, USA.
- Masuda, A. 2010. Natal Origin of Juvenile Loggerhead Turtles from Foraging Ground in Nicaragua and Panama Estimated Using Mitochondria DNA. California State University, Chico, California.
- Mather, J. 2004. Cephalopod skin displays: From concealment to communication. D. K. O. U. Griebel, editor. *The Evolution of Communication Systems: A Comparative Approach*. The Vienna Series in Theoretical Biology and the Massachusetts Institute of Technology, Cambridge, Massachusetts.
- Matthews, J. N., and coauthors. 2001. Vocalisation rates of the North Atlantic right whale (*Eubalaena glacialis*). *Journal of Cetacean Research and Management* 3(3):271–282.
- Matthews, L. P., J. A. McCordic, and S. E. Parks. 2014. Remote acoustic monitoring of North Atlantic right whales (*Eubalaena glacialis*) reveals seasonal and diel variations in acoustic behavior. *PLoS One* 9(3):e91367.

- Matthews, L. P., and S. E. Parks. 2021. An overview of North Atlantic right whale acoustic behavior, hearing capabilities, and responses to sound. *Marine Pollution Bulletin* 173:113043.
- Mayne, B., A. D. Tucker, O. Berry, and S. Jarman. 2020. Lifespan estimation in marine turtles using genomic promoter CpG density. *PLoS One* 15(7):e0236888.
- Mayo, C. A., and coauthors. 2018. Distribution, demography, and behavior of North Atlantic right whales (*Eubalaena glacialis*) in Cape Cod Bay, Massachusetts, 1998–2013. *Marine Mammal Science* 34(4):979-996.
- Mazaris, A., and coauthors. 2009. Assessing the relative importance of conservation measures applied on sea turtles: comparison of measures focusing on nesting success and hatching recruitment success. *Amphibia-Reptilia* 30(2):221-231.
- Maze-Foley, K., and K. Mullin. 2006. Cetaceans of the oceanic northern Gulf of Mexico: Distributions, group sizes and interspecific associations. *J. Cetacean Res. Manage.* 8(2):203-213.
- Mccarthy, E., and coauthors. 2011. Changes in spatial and temporal distribution and vocal behavior of Blainville's beaked whales (*Mesoplodon densirostris*) during multiship exercises with mid-frequency sonar. *Marine Mammal Science* 27(3):E206-E226.
- McCarthy, K. 2007. A Review of Queen Conch (*strombus Gigas*) Life-history. NOAA National Marine Fisheries Service, Southeast Fisheries Science Center.
- McCauley, D. J., and coauthors. 2015. Marine defaunation: animal loss in the global ocean. *Science* 347(6219):1255641.
- McCauley, R. D., and coauthors. 2017. Widely used marine seismic survey air gun operations negatively impact zooplankton. *Nature Ecology and Evolution* 1(7):195.
- McCauley, R. D., and coauthors. 2000a. Marine seismic surveys - A study of environmental implications. *APPEA Journal*:692-708.
- McCauley, R. D., and coauthors. 2000b. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Curtin University of Technology, Western Australia.
- McCauley, R. D., M. N. Jenner, C. Jenner, K. A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. *Australian Petroleum Production and Exploration Association Journal*:692–706.
- Mcclellan, C. M., J. Braun-Mcneill, L. Avens, B. P. Wallace, and A. J. Read. 2010. Stable isotopes confirm a foraging dichotomy in juvenile loggerhead sea turtles. *Journal of Experimental Marine Biology and Ecology* 387:44-51.
- McCordic, J. A., H. Root-Gutteridge, D. A. Cusano, S. L. Denes, and S. E. Parks. 2016. Calls of North Atlantic right whales *Eubalaena glacialis* contain information on individual identity and age class. *Endangered Species Research* 30:157-169.
- McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon.
- McDonald, M. A., J. Calambokidis, A. M. Teranishi, and J. A. Hildebrand. 2001. The acoustic calls of blue whales off California with gender data. *Journal of the Acoustical Society of America* 109(4):1728-1735.

- McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. *Journal of the Acoustical Society of America* 98(2 Part 1):712-721.
- McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. *Journal of the Acoustical Society of America* 120(2):711-718.
- McDonald, M. A., and coauthors. 2005. Sei whale sounds recorded in the Antarctic. *The Journal of Acoustical Society of America* 118(6):3941-3945.
- McDonald, M. A., and S. E. Moore. 2002. Calls recorded from North Pacific right whales (*Eubalaena japonica*) in the eastern Bering Sea. *Journal of Cetacean Research and Management* 4(3):261-266.
- McKenna, M. F., J. Calambokidis, E. M. Oleson, D. W. Laist, and J. A. Goldbogen. 2015. Simultaneous tracking of blue whales and large ships demonstrates limited behavioral responses for avoiding collision. *Endangered Species Research* 27(3):219-232.
- McKenna, M. F., D. Ross, S. M. Wiggins, and J. A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. *Journal of the Acoustical Society of America* 131(2):92-103.
- McLennan, M. W. 1997. A simple model for water impact peak pressure and width: A technical memorandum.
- McLeod, B. A., M. W. Brown, T. R. Frasier, and B. N. White. 2010. DNA profile of a sixteenth century western North Atlantic right whale (*Eubalaena glacialis*). *Conservation Genetics* 11(1):339-345.
- McLeod, B. A., and B. N. White. 2010. Tracking mtDNA heteroplasmy through multiple generations in the North Atlantic right whale (*Eubalaena glacialis*). *Journal of Heredity* 101(2):235-239.
- McMahon, C. R., and G. C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. *Global change biology* 12(7):1330-1338.
- McMinn, A., G. Hallegraeff, P. Thomson, A. V. Jenkinson, and H. Heijnis. 1997. Cyst and radionucleotide evidence for the recent introduction of the toxic dinoflagellate *Gymnodinium catenatum* into Tasmanian waters. *Marine Ecology-Progress Series* 161:65-172.1.
- McNally, K., and coauthors. 2024. Nesting Trends of Sea Turtles in North and Mid Pinellas County, Florida, USA, Over Three Decades. *Herpetological Conservation and Biology* 19(3):440-453.
- McQuinn, I. H., and P. Nellis. 2007. An acoustic-trawl survey of middle St. Lawrence Estuary demersal fishes to investigate the effects of dredged sediment disposal on Atlantic sturgeon and lake sturgeon distribution. Pages 257 in *American Fisheries Society Symposium*. American Fisheries Society.
- Medeiros, A., O. Luiz, and C. Domit. 2015. Occurrence and use of an estuarine habitat by giant manta ray *Manta birostris*. *Journal of Fish Biology* 86(6):1830-1838.
- Meissner, A. M., and coauthors. 2015. Behavioural effects of tourism on oceanic common dolphins, *Delphinus* sp, in New Zealand: The effects of Markov analysis variations and current tour operator compliance with regulations. *PLoS One* 10(1):e116962.
- Melcon, M. L., and coauthors. 2012. Blue whales respond to anthropogenic noise. *PLoS One* 7(2):e32681.

- Mellinger, D. K., and C. W. Clark. 2003. Blue whale (*Balaenoptera musculus*) sounds from the North Atlantic. *Journal of the Acoustical Society of America* 114(2):1108-1119.
- Melnichuk, M. C., K. J. Dunton, A. Jordaan, K. A. McKown, and M. G. Frisk. 2017. Informing conservation strategies for the endangered Atlantic sturgeon using acoustic telemetry and multi-state mark-recapture models. *Journal of Applied Ecology* 54(3):914-925.
- Mercado-Molina, A. E., C. P. Ruiz-Diaz, M. E. Pérez, R. Rodríguez-Barreras, and A. M. Sabat. 2015. Demography of the threatened coral *Acropora cervicornis*: implications for its management and conservation. *Coral Reefs*.
- Mercado-Molina, A. E., C. P. Ruiz-Diaz, and A. M. Sabat. 2018. Tissue loss rather than colony size determines the demographic fate of the branching coral *Acropora cervicornis*. *Marine Ecology Progress Series* 597:147-159.
- Mesnick, S. L., and coauthors. 2011. Sperm whale population structure in the eastern and central North Pacific inferred by the use of single-nucleotide polymorphisms, microsatellites and mitochondrial DNA. *Molecular Ecology Resources* 11 Suppl 1:278-98.
- Meyer-Gutbrod, E. L., and coauthors. 2023. Redefining North Atlantic right whale habitat-use patterns under climate change. *Limnology and Oceanography* 68:S71-S86.
- Meyer, M., and A. N. Popper. 2002. Hearing in "primitive" fish: Brainstem responses to pure tone stimuli in the lake sturgeon, *Acipenser fulvescens*. *Abstracts of the Association for Research in Otolaryngology* 25:11-12.
- Milessi, A. C., and M. C. Oddone. 2003. Primer registro de Manta birostris (Donndorff 1798)(Batoidea: Mobulidae) en el Rio de La Plata, Uruguay. *Gayana (Concepción)* 67(1):126-129.
- Miller, C. A., and coauthors. 2011. Blubber thickness in right whales *Eubalaena glacialis* and *Eubalaena australis* related with reproduction, life history status and prey abundance. *Marine Ecology Progress Series* 438:267-283.
- Miller, J. D., K. A. Dobbs, C. J. Limpus, N. Mattocks, and A. M. Landry. 1998. Long-distance migrations by the hawksbill turtle, *Eretmochelys imbricata*, from north-eastern Australian. *Wildlife Research* 25:89-95.
- Miller, M. H., C. Klimovich 2017. Endangered Species Act Status Review Report: Giant Manta Ray (*Manta birostris*) and Reef Manta Ray (*Manta alfredi*). Silver Spring, Maryland.
- Miller, M. H., and coauthors. 2014. Status review report: scalloped hammerhead shark (*Sphyrna lewini*). Final Report to NMFS, Office of Protected Resources.
- Miller, M. W. 2014. Post-settlement survivorship in two Caribbean broadcasting corals. *Coral Reefs* 33:1041–1046.
- Miller, M. W., I. B. Baums, and D. E. Williams. 2007. Visual discernment of sexual recruits is not feasible for *Acropora palmata*. *Marine Ecology Progress Series* 335:227-231.
- Miller, M. W., K. Kerr, and D. E. Williams. 2016a. Reef-scale trends in Florida *Acropora* spp. abundance and the effects of population enhancement. *PeerJ* 4:e2523.
- Miller, M. W., D. E. Williams, and J. Fisch. 2016b. Genet-specific spawning patterns in *Acropora palmata*. *Coral Reefs*.
- Miller, P. J. O., N. Biassoni, A. Samuels, and P. L. Tyack. 2000. Whale songs lengthen in response to sonar. *Nature* 405(6789):903.
- Miller, P. J. O., and coauthors. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep Sea Research I* 56(7):1168–1181.

- Miller, P. J. O., M. P. Johnson, and P. L. Tyack. 2004. Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. *Proceedings of the Royal Society of London Series B Biological Sciences* 271(1554):2239-2247.
- Miller, P. J. O., and coauthors. 2012. The severity of behavioral changes observed during experimental exposures of killer (*Orcinus orca*), long-finned pilot (*Globicephala melas*), and sperm (*Physeter macrocephalus*) whales to naval sonar. *Aquatic Mammals* 38(4):362-401.
- Miller, S. L., M. Chiappone, L. M. Rutten, and D. W. Swanson. 2008. Population status of *Acropora corals* in the Florida Keys. *Proceedings of the 11th International Coral Reef Symposium*:775-779.
- Miller, S. L., W. F. Precht, L. M. Rutten, and M. Chiappone. 2013. Florida Keys Population Abundance Estimates for Nine Coral Species Proposed for Listing Under the U.S. Endangered Species Act., 1(1), Dania Beach, Florida.
- Mintz, J. D. 2016. Characterization of Vessel Traffic in the Vicinities of HRC, SOCAL, and the Navy Operating Areas off the U.S. East Coast. Center for Naval Analyses, Alexandria, VA.
- Mintz, J. D., and R. J. Filadelfo. 2011. Exposure of Marine Mammals to Broadband Radiated Noise, CRM D0024311.A2/Final.
- Misund, O. A. 1997. Underwater acoustics in marine fisheries and fisheries research. *Reviews in Fish Biology and Fisheries* 7:1–34.
- Mitchell, R., I. MacDonald, and K. Kvenvolden. 1999. Estimates of total hydrocarbon seepage into the Gulf of Mexico based on satellite remote sensing images. *EOS Supplement* 80(49):OS242.
- Mitson, R. B., and H. P. Knudsen. 2003. Causes and effects of underwater noise on fish abundance estimation. *Aquatic Living Resources* 16(3):255-263.
- Mitton, J. B., C. J. Berg, and K. S. Orr. 1989. Population Structure, Larval Dispersal, and Gene Flow in the Queen Conch, *Strombus gigas*, of the Caribbean. *The Biological Bulletin* 177(3):356-362.
- MMC. 2007. Marine mammals and noise: A sound approach to research and management. Marine Mammal Commission.
- MMS. 1998. Pages III-3 to III-72 in Gulf of Mexico OCS oil and gas lease sales 171, 174, 177, and 180—Western Planning Area. Minerals Management Service, New Orleans, Louisiana.
- Moberg, G. P. 2000. Biological response to stress: Implications for animal welfare. Pages 21-Jan in J. A. G. P. M. Moberg, editor. *The Biology of Animal Stress*. Oxford University Press, Oxford, United Kingdom.
- Mobley, J. R. 2011. Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with Two Navy Training Events. SCC and USWEX February 16–March 5, 2011. Final Field Report. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, HI, 96860-3134, under Contract # N6247010D3011, CTO KB07. Submitted by HDR Inc., San Diego.
- Mobley, J. R., and M. H. Deakos. 2015. Aerial Shoreline Surveys for Marine Mammals and Sea Turtles in the Hawaii Range Complex, Conducted after Navy Training Events. Koa Kai Surveys: 31 January and 5 February 2014. RIMPAC Surveys: 1 and 4–6 July 2014 (Prepared for Naval Facilities Engineering Command Pacific for Commander, U.S.

- Pacific Fleet under Contract No. N62470-10-D-3011, CTO KB26, issued to HDR, Inc.).
Pearl Harbor, HI: HDR Inc.
- Mobley, J. R., and A. Pacini. 2012. Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with a Navy Training Event, SCC February 15–25, 2010, Final Field Report. Prepared for Commander, Pacific Fleet Environmental. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, HI, 96860-3134, under Contract No. N62470-10-D-3011. Submitted by HDR Inc, Honolulu, HI, July 25, 2012.
- Moein, S. E., and coauthors. 1995. Evaluation of seismic sources for repelling sea turtles from hopper dredges. Pages 75-78 *in* L. Z. Hales, editor. Sea Turtle Research Program: Summary report. Prepared for U.S. Army Corps of Engineers, South Atlantic, Atlanta GA and U.S. Naval Submarine Base, Kings Bay, GA.
- Mohammed, A., and T. Mohammed. 2017. Mercury, arsenic, cadmium and lead in two commercial shark species (*Sphyrna lewini* and *Caraharinus porosus*) in Trinidad and Tobago. *Marine Pollution Bulletin* 119(2):214-218.
- Mohl, B., M. Wahlberg, P. T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. *Journal of the Acoustical Society of America* 114(2):1143-1154.
- Moncheva, S. P., and L. T. Kamburska. 2002. Plankton stowaways in the Black Sea - Impacts on biodiversity and ecosystem health. Pages 47-51. CIESM Workshop Monographs [CIESM Workshop Monogr.]. 2002. *in* Alien marine organisms introduced by ships in the Mediterranean and Black seas.
- Monsarrat, S., and coauthors. 2016. A spatially explicit estimate of the prewhaling abundance of the endangered North Atlantic right whale. *Conservation Biology* 30(4):783-791.
- Montero, N., and coauthors. 2018. Warmer and wetter conditions will reduce offspring production of hawksbill turtles in Brazil under climate change. *PLoS One* 13(11):e0204188.
- Montie, E. W., and coauthors. 2010. Brominated flame retardants and organochlorine contaminants in winter flounder, harp and hooded seals, and North Atlantic right whales from the Northwest Atlantic Ocean. *Marine Pollution Bulletin* 60(8):1160-1169.
- Monzon-Arguello, C., C. Rico, A. Marco, P. Lopez, and L. F. Lopez-Jurado. 2010. Genetic characterization of eastern Atlantic hawksbill turtles at a foraging group indicates major undiscovered nesting populations in the region. *Journal of Experimental Marine Biology and Ecology* in press(in press):in press.
- Moore, A. 2012. Records of poorly known batoid fishes from the north-western Indian Ocean (Chondrichthyes: Rhynchobatidae, Rhinobatidae, Dasyatidae, Mobulidae). *African Journal of Marine Science* 34(2):297-301.
- Moore, J. E., and J. P. Barlow. 2017. Population abundance and trend estimates for beaked whales and sperm whales in the California Current based on ship-based visual line-transect survey data, 1991 – 2014. U.S. Department of Commerce, NOAA.
- Moore, M. J., and coauthors. 2021. REVIEW Assessing North Atlantic right whale health: Threats, and development of tools critical for conservation of the species. *Diseases of Aquatic Organisms* 143:205-226.
- Moore, M. J., and J. M. Van der Hoop. 2012. The painful side of trap and fixed net fisheries: chronic entanglement of large whales. *Journal of Marine Biology* 2012.

- Moore, S. E., and R. P. Angliss. 2006. Overview of planned seismic surveys offshore northern Alaska, July-October 2006. Paper SC/58/E6 presented to IWC Scientific Committee, St Kitts and Nevis.
- Morales Tirado, J. A. 2006. Sexual reproduction in the Caribbean coral genus *Mycetophyllia*, in La Parguera, Puerto Rico. University of Puerto Rico, Mayaguez.
- Morano, J. L., and coauthors. 2012. Acoustically detected year-round presence of right whales in an urbanized migration corridor. *Conservation Biology* 26(4):698-707.
- Morano, J. L., and coauthors. 2020. Seasonal movements of Gulf of Mexico sperm whales following the Deepwater Horizon oil spill and the limitations of impact assessments. *Marine Pollution Bulletin* 161:111627.
- Moretti, D., and coauthors. 2009. An opportunistic study of the effect of sonar on marine mammals, marine mammal monitoring on navy ranges (M3R). 2009 ONR Marine Mammal Program Review, Alexandria, Virginia.
- Moretti, D., and coauthors. 2014. A risk function for behavioral disturbance of Blainville's beaked whales derived via passive acoustic monitoring. Pages 53 in *Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014)*, Amsterdam, The Netherlands.
- Morin, H. 2024. Criteria for Effects of Anthropogenic Sound on Fishes.
- Moser, M. L., and S. W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the lower Cape Fear River, North Carolina. *Transactions of the American Fisheries Society* 124(2):225.
- Mourier, J. 2012. Manta rays in the Marquesas Islands: first records of *Manta birostris* in French Polynesia and most easterly location of *Manta alfredi* in the Pacific Ocean, with notes on their distribution. *Journal of Fish Biology* 81(6):2053-2058.
- MPI. 2013. Overview of ecological effects of aquaculture., Wellington, New Zealand.
- MSPO. 1993. Kennebec River Resource Management Plan.
- Muller, E. M., C. S. Rogers, and R. Woesik. 2014. Early signs of recovery of *Acropora palmata* in St. John, US Virgin Islands. *Marine Biology* 161:359-365.
- Murawski, S. A., D. J. Hollander, S. Gilbert, and A. Gracia. 2020. Deepwater Oil and Gas Production in the Gulf of Mexico and Related Global Trends. Pages 16-32 in S. A. Murawski, and coeditors, editors. *Scenarios and Responses to Future Deep Oil Spills: Fighting the Next War*. Springer International Publishing, Cham.
- Murawski, S. A., and A. L. Pacheco. 1977. Biological and fisheries data on Atlantic sturgeon, *Acipenser oxyrinchus* (Mitchill).
- Murray, K. T. 2015. Estimated loggerhead (*Caretta caretta*) interactions in the Mid-Atlantic scallop dredge fishery, 2009-2014. National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts.
- Murray, K. T. 2018. Estimated bycatch of sea turtles in sink gillnet gear. National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts.
- Murray, K. T. 2020. Estimated magnitude of sea turtle interactions and mortality in U.S. bottom trawl gear, 2014-2018. National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts.
- Musick, J. A., and C. J. Limpus. 1997. Habitat utilization, and migration in juvenile sea turtles. Pages 137-163 in P. L. Lutz, and J. A. Musick, editors. *The biology of sea turtles*. CRC Press, Boca Raton, Florida.

- Mussoline, S. E., and coauthors. 2012. Seasonal and diel variation in North Atlantic right whale up-calls: Implications for management and conservation in the northwestern Atlantic Ocean. *Endangered Species Research* 17(1-Jan):17-26.
- Myrberg, A. A. 1978. Underwater sound-its effect on the behavior of sharks. Pages 391-417 in E. S. Hodgson, and R. F. Mathewson, editors. *Sensory biology of sharks, skates, and rays*. U.S. Office of Naval Research, Arlington, Virginia.
- Myrberg, A. A. 2001. The acoustical biology of elasmobranchs. *Environmental Biology of Fishes* 60(31-45).
- Myrberg, A. A., C. R. Gordon, and A. P. Klimley. 1975. Attraction of Free-Ranging Sharks by Acoustic Signals in the Near-Subsonic Range. Rosenstiel School of Marine and Atmospheric Science, TR75-4, University of Miami, Tech. Rept. to Office of Nav. Res., Contract No. N00014-67-A-0201-0008, Coral Gables, Florida.
- Myrberg, A. A., C. R. Gordon, and A. P. Klimley. 1976. Attraction of free ranging sharks by low frequency sound, with comments on its biological significance. A. S. A. D. Hawkins, editor. *Sound Reception in Fish*. Elsevier, Amsterdam.
- Myrberg, A. A., C. R. Gordon, and A. P. Klimley. 1978. Rapid withdrawal from a sound source by open-ocean sharks. *The Journal of Acoustical Society of America* 64:1289-1297.
- Myrberg Jr., A. A. 2001. The acoustical biology of elasmobranchs. *Environmental Biology of Fishes* 60(1):16.
- Nachtigall, P. E., and A. Y. Supin. 2013. False killer whales (*Pseudorca crassidens*) reduce their hearing sensitivity if a loud sound is preceded by a warning. Pages 153-154 in *Twentieth Biennial Conference on the Biology of Marine Mammals*, Dunedin, New Zealand.
- Nachtigall, P. E., A. Y. Supin, A. B. Smith, and A. F. Pacini. 2016. Expectancy and conditioned hearing levels in the bottlenose dolphin (*Tursiops truncatus*). *Journal of Experimental Biology* 219(Pt 6):844-50.
- Nadeem, K., J. E. Moore, Y. Zhang, and H. Chipman. 2016. Integrating population dynamics models and distance sampling data: A spatial hierarchical state-space approach. *Ecology* 97(7):1735-1745.
- NALWG. 2018. Northwest Atlantic Leatherback Turtle Status Assessment. Northwest Atlantic Leatherback Working Group.
- Narazaki, T., K. Sato, K. J. Abernathy, G. J. Marshall, and N. Miyazaki. 2013. Loggerhead turtles (*Caretta caretta*) use vision to forage on gelatinous prey in mid-water. *PLoS One* 8(6):e66043.
- NAS. 2017. Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. National Academies of Sciences, Engineering, and Medicine. The National Academies Press, Washington, District of Columbia.
- National Academies of Sciences, E., and Medicine. 2016. Approaches to understanding the cumulative effects of stressors on marine mammals. National Academies Press.
- National Marine Fisheries Service. 2011. Final Recovery Plan for the Sei Whale (*Balaenoptera borealis*). Pages 107 in. National Marine Fisheries Service Office of Protected Resources, Silver Spring, MD.
- National Marine Fisheries Service. 2013. Nassau Grouper, *Epinephelus striatus* (Bloch 1792) Biological Report. National Marine Fisheries Service, Silver Spring, MD.
- Navy. 2013. Water Range Sustainability Environmental Program Assessment, Potomac River Test Range Complex. Dahlgren, VA.

- Navy. 2017. Atlantic Fleet Training and Testing Biological Assessment. Naval Facilities Engineering Command, Atlantic; Space and Naval Warfare Systems Command.
- Navy. 2021. Biological Assessment for Reinitiation of Formal Consultation Under Section 7 of the Endangered Species Act for Ongoing Military Readiness Activities in the Hawaii-Southern California Training and Testing Study Area. Commander, United States Pacific Fleet and Commander, Naval Sea Systems Command, Department of the Navy
- Navy. 2022a. Lookout Training Handbook NAVEDTRA 12968-E.
- Navy. 2022b. NMFS Follow Up Questions and Requests for Additional Information On the Navy's Biological Assessment for Re-Initiation of HSTT. Pages 8 *in*. Department of the Navy.
- Navy. 2022c. Supplement NMFS Follow Up Questions and Requests for Additional Information On the Navy's Biological Assessment for Re-Initiation of HSTT. Pages 6 *in*. OPNAV N4154 Environmental Planning & Conservation Branch, Department of the Navy.
- Navy. 2024a. Addendum information (submitted October 25, 2024) to support Atlantic Fleet Training and Testing (AFTT) Biological Assessment (submitted on August 23, 2024). Pages 13 *in*. Navy, U.S. Fleet Forces, Environmental Readiness Division.
- Navy. 2024b. AFFT 2024 EIS/OIS Appendix F Military Expended Material and Direct Strike Impact Analysis
- Navy. 2024c. Atlantic Fleet Training and Testing Activities Final Biological Assessment (Final). United States Fleet Forces Command, Norfolk, VA.
- Navy. 2024d. Atlantic Fleet Training and Testing Supplemental EIS/OEIS Final: Appendix A - Activity Descriptions.
- Navy. 2024e. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase 4). Naval Information Warfare Center Pacific, San Diego, CA.
- Navy. 2024f. Dive Distribution and Group Size Parameters for Marine Species Occurring in the U.S. Navy's Atlantic and Hawaii-California Training and Testing Study Areas Naval Undersea Warfare Center Division Newport, Rhode Island
- Navy. 2024g. Phase IV Atlantic Fleet Training and Testing: Marine Habitat Database Technical Report.
- Navy. 2024h. Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase IV Training and Testing, Naval Undersea Warfare Center Division, Newport, Rhode Island.
- Navy. 2024i. Request for Regulations and LOA for the Incidental Taking of Marine Mammals Resulting from Military Readiness Activities in the Atlantic Fleet Training and Testing Study Area. Commander, United States Fleet Forces Command, Norfolk, Virginia.
- Navy. 2024j. U.S. Navy Marine Species Density Database Phase IV for the Atlantic Fleet Training and Testing Study Area, Naval Facilities Engineering Systems Command Atlantic, Norfolk, VA. .
- Navy. 2025a. AFTT Biological Assessment Addendum, May 2025.
- Navy. 2025b. Atlantic Fleet Training and Testing Final Supplemental EIS/OEIS: Appendix E. Acoustic and Explosive Impacts Analysis for Marine Mammals, Reptiles, and Fishes in the Atlantic Fleet Training and Testing Study Area (Version 3).
- Navy. 2025c. NMFS questions and recommendations to Action Proponents RE AFTT_Navy Response.
- Navy, D. o. t. 2020. Integrated Natural Resources Management Plan for Naval Air Station Key West Florida N. F. E. C. Southeast, editor.

- Navy, U. S. D. o. t. 2024k. Phase IV Atlantic Fleet Training and Testing: Marine Habitat Database Technical Report.
- NCDMF. 2014. Application for an individual incidental take permit under the Endangered Species Act of 1973: Atlantic sturgeon (*Acipenser oxyrinchus*). North Carolina Division of Marine Fisheries.
- Neely, K. 2018. Surveying the Florida Keys Southern Coral Disease Boundary, Florida DEP. Miami, FL.
- Neely, K. L., C. Lewis, A. N. Chan, and I. B. Baums. 2018. Hermaphroditic spawning by the gonochoric pillar coral *Dendrogyra cylindrus*. *Coral Reefs* 37(4):1087-1092.
- Neely, K. L., C. L. Lewis, and K. A. Macaulay. 2020. Disparities in Spawning Times Between in situ and ex situ Pillar Corals. *Frontiers in Marine Science* 7(643).
- Neely, K. L., K. S. Lunz, and K. A. Macaulay. 2013. Simultaneous gonochoric spawning of *Dendrogyra cylindrus*. *Coral Reefs* 32(3):813-813.
- Nellis, P., and coauthors. 2007. Macrobenthos assemblages in the St. Lawrence estuarine transition zone and their potential as food for Atlantic sturgeon and lake sturgeon. Pages 105 in *American Fisheries Society Symposium*. American Fisheries Society.
- Nelms, S. E., W. E. D. Piniak, C. R. Weir, and B. J. Godley. 2016. Seismic surveys and marine turtles: An underestimated global threat? *Biological Conservation* 193:49-65.
- Nelson, D. R., and S. H. Gruber. 1963. Sharks: Attraction by Low-Frequency Sounds. *Science* 142(3594):975-7.
- Nelson, D. S., and coauthors. 2016. Predicting dredging-associated effects to coral reefs in Apra Harbor, Guam - Part 2: Potential coral effects. *Journal of Environmental Management* 168:111-122.
- Nemeth, R. S., and coauthors. 2008. Characterization of Deep Water Reef Communities within the Marine Conservation District, St. Thomas, US Virgin Islands.
- New, L. F., and coauthors. 2014. Using short-term measures of behaviour to estimate long-term fitness of southern elephant seals. *Marine Ecology Progress Series* 496:99-108.
- Nichols, T., T. Anderson, and A. Sirovic. 2015. Intermittent noise induces physiological stress in a coastal marine fish. *PLoS ONE*, 10(9), e0139157. .
- Nieukirk, S. L., and coauthors. 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999-2009. *The Journal of Acoustical Society of America* 131(2):1102-1112.
- Nieukirk, S. L., K. M. Stafford, D. K. Mellinger, R. P. Dziak, and C. G. Fox. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. *Journal of the Acoustical Society of America* 115(4):1832-1843.
- NMFS. 1998a. Final Recovery Plan for the Shortnose Sturgeon *Acipenser brevirostrum*. Pages 104 in *Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, editor, Silver Spring, Maryland.*
- NMFS. 1998b. Recovery plan for the blue whale (*Balaenoptera musculus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, Maryland.
- NMFS. 2004a. Endangered Species Act Section 7 Consultation - Biological Opinion on Naval Explosive Ordnance Disposal School (NEODS) training, 5-year plan, Eglin AFB, Florida.
- NMFS. 2004b. Endangered Species Act Section 7 Consultation - Biological Opinion on the Eglin Gulf test and training range.

- NMFS. 2005a. Endangered Species Act Section 7 Consultation - Biological Opinion on the continued authorization of reef fish fishing under the Gulf of Mexico Reef Fish Fishery Management Plan and Proposed Amendment 23.
- NMFS. 2005b. Endangered Species Act Section 7 Consultation - Biological Opinion on Eglin Gulf Test and Training Range, Precision Strike Weapons (PSW) Test (5-Year Plan).
- NMFS. 2005c. Endangered Species Act Section 7 Consultation - Biological Opinion on the Santa Rosa Island mission utilization plan.
- NMFS. 2005d. Recovery plan for the North Atlantic right whale (*Eubalaena glacialis*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service.
- NMFS. 2006. Biological opinion on the issuance of section 10(a)(1)(A) permits to conduct scientific research on the southern resident killer whale (*Orcinus orca*) distinct population segment and other endangered or threatened species. National Marine Fisheries Service, Northwest Region, Seattle, Washington.
- NMFS. 2009a. Smalltooth sawfish recovery plan (*Pristis pectinata*). N. M. F. S. NOAA, editor. Smalltooth Sawfish Recovery Team, Silver Spring, Maryland.
- NMFS. 2010a. Final recovery plan for the sperm whale (*Physeter macrocephalus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 2010b. Recovery plan for the fin whale (*Balaenoptera physalus*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 2010c. Smalltooth sawfish (*Pristis pectinata*) 5-year review: summary and evaluation. N. O. A. A. National Marine Fisheries Service, Commerce, editor. Protected Resources Division, St. Petersburg, FL.
- NMFS. 2011a. Final recovery plan for the sei whale (*Balaenoptera borealis*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 2011b. Reducing Vessel Strikes of Large Whales in California. NOAA, NMFS, Southeast Regional Office.
- NMFS. 2012. ESA Section 7 Consultation on an assessment of the United States Coast Guard's National Ballast Water Management Program and Initial Numerical Standard. U.S. Dept. of Commerce, NOAA, NMFS, Silver Spring, MD.
- NMFS. 2013a. Endangered Species Act Section 7 Consultation - Biological Opinion on the Eglin Air Force Base Maritime Strike Operations Tactics Development and Evaluation. Submitted on May 6, 2013. National Marine Fisheries Service, St. Petersburg, Florida.
- NMFS. 2013b. Endangered Species Act Section 7 Consultation on the Continued Implementation of Management Measures for the Northeast Multispecies, Monkfish, Spiny Dogfish, Atlantic Bluefish, Northeast Skate Complex, Mackerel/Squid/Butterfish, and Summer Flounder/Scup/Black Sea Bass Fisheries. O. National Marine Fisheries Service. Greater Atlantic Regional Fisheries, editor. National Marine Fisheries Service, Northeast Regional Office, Protected Resources Division.
- NMFS. 2013c. Hawksbill sea turtle (*Eremochelys imbricata*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service.
- NMFS. 2014a. ESA Section 7 Consultation for Permit Number 17787 (Southeast Fisheries Science Center) to Authorize Research on Smalltooth Sawfish along the Coast of Florida. N. O. A. A. National Marine Fisheries Service, Commerce, editor. Protected Resources.

- NMFS. 2014b. Queen conch, *Strombus gigas* (Linnaeus 1758) status report. National Marine Fisheries Service.
- NMFS. 2015a. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Deepwater Wind: Block Island Wind Farm and Transmission System. NER-2015-12248 GARFO-2015-00031. National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office.
- NMFS. 2015b. Recovery plan for elkhorn coral (*Acropora palmata*) and staghorn coral (*A. cervicornis*).
- NMFS. 2015c. Sperm Whale (*Physeter macrocephalus*) 5-Year Review : Summary and Evaluation.
- NMFS. 2016a. Interim Guidance on the Endangered Species Act Term "Harass." December 2016. Protected Resources Management. National Marine Fisheries Service Procedural Instruction 02-110-10. .
- NMFS. 2016b. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Virginia Offshore Wind Technology Advancement Project. NER-2015-12128 GARFO-2015-00030. National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office.
- NMFS. 2017a. Biological and Conference Opinion on the Proposed Implementation of a Program for the Issuance of Permits for Research and Enhancement Activities on Atlantic and Shortnose Sturgeon Pursuant to Section 10(a) of the Endangered Species Act. Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service.
- NMFS. 2017b. Biological Opinion for Ongoing Eglin Gulf Testing and Training Range Activities. National Marine Fisheries Service, FPR-2016-9151, Silver Spring, MD.
- NMFS. 2017c. North Atlantic Right Whale (*Eubalaena glacialis*) 5-Year Review: Summary and Evaluation. Greater Atlantic Regional Fisheries Office, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Gloucester, Massachusetts.
- NMFS. 2018a. Biological and Conference Opinion on U.S. Navy Atlantic Fleet Training and Testing and the National Marine Fisheries Service's Promulgation of Regulations Pursuant to the Marine Mammal Protection Act for the Navy to "Take" Marine Mammals Incidental to Atlantic Fleet Training and Testing. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.
- NMFS. 2018b. Smalltooth Sawfish (*Pristis pectinata*) 5-Year Review: Summary and Evaluation of United States Distinct Population Segment of Smalltooth Sawfish. National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, Florida.
- NMFS. 2019a. Biological and Conference Opinion on the Proposed Implementation of a Program for the Issuance of Permits for Research and Enhancement Activities on Cetaceans in the Arctic, Atlantic, Indian, Pacific, and Southern Oceans Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.
- NMFS. 2019b. Endangered and Threatened Species; Determination on the Designation of Critical Habitat for Giant Manta Ray. NOAA, editor 84 FR 66652.

- NMFS. 2019c. Fin Whale (*Balaenoptera physalus*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office Protected Resources, Silver Spring, MD.
- NMFS. 2019d. Giant Manta Ray Recovery Outline.
- NMFS. 2019e. Memo for the Record: Biological and Conference Opinion on U.S. Navy Atlantic Fleet Training and Testing and the National Marine Fisheries Service's Promulgation of Regulations Pursuant to the Marine Mammal Protection Act for the Navy to "Take" Marine Mammals Incidental to Atlantic Fleet Training and Testing.
- NMFS. 2020a. Blue Whale (*Balaenoptera musculus*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD.
- NMFS. 2020b. Recovery Plan for the Blue Whale (*Balaenoptera musculus*): First Revision to the July 1998 Recovery Plan for the Blue Whale. Office of Protected Resources and West Coast Region, National Marine Fisheries Service.
- NMFS. 2021a. Construction, Operation, Maintenance, and Decommissioning of the South Fork Offshore Energy Project (Lease OCS-A 0517). GARFO-2021-00353. National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office.
- NMFS. 2021b. ESA Section 7 Consultation Biological Opinion on the: (a) Authorization of the American Lobster, Atlantic Bluefish, Atlantic Deep-Sea Red Crab, Mackerel/Squid/Butterfish, Monkfish, Northeast Multispecies, Northeast Skate Complex, Spiny Dogfish, Summer Flounder/Scup/Black Sea Bass, and Jonah Crab Fisheries and (b) Implementation of the New England Fishery Management Council's Omnibus Essential Fish Habitat Amendment 2 National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, Protected Resources Division.
- NMFS. 2021c. National Marine Fisheries Service Endangered Species Act Section 7 Biological Opinion Construction, Operation, Maintenance, and Decommissioning of the Vineyard Wind 1 Offshore Wind Energy Project (Lease OCS-A 0501) - Reinitiation. GARFO-2019-00343. National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office.
- NMFS. 2021d. Recovery Outline: Rice's Whale. NMFS Southeast Regional Office Accessed online from: <https://www.fisheries.noaa.gov/resource/document/rices-whale-recovery-outline>
- NMFS. 2021e. Sei Whale (*Balaenoptera borealis*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD.
- NMFS. 2021f. US Atlantic and Gulf of Mexico marine mammal stock assessments 2020.
- NMFS. 2022a. New York Bight Distinct Population Segment of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, Gloucester, Massachusetts.
- NMFS. 2022b. North Atlantic Right Whale (*Eubalaena glacialis*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Greater Atlantic Regional Office, Gloucester, MA.
- NMFS. 2022c. Staghorn coral (*Acropora cervicornis*), elkhorn coral (*Acropora palmata*), lobed star coral (*Orbicella annularis*), mountainous star coral (*Orbicella faveolata*), boulder star coral (*Orbicella franksi*), rough cactus coral (*Mycetophyllia ferox*), and pillar coral (*Dendrogyra cylindrus*) 5-year review. United States. National Marine Fisheries Service. Southeast, Region. <https://doi.org/10.25923/jyer-dv55>.

- NMFS. 2023a. Construction, Operation, Maintenance, and Decommissioning of the Ocean Wind 1 Offshore Energy Project (Lease OCS-A 0498) GARFO-2022-02397. National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office.
- NMFS. 2023b. Draft Biological Report for the Designation of Marine Critical Habitat for Six Distinct Population Segments of the Green Turtle, *Chelonia mydas*. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.
- NMFS. 2023c. Endangered Species Act Recovery Status Review for the Oceanic Whitetip Shark (*Carcharhinus longimanus*). NOAA, National Marine Fisheries Service.
- NMFS. 2023d. Endangered Species Act Rice's Whale Critical Habitat Report: Proposed Information Basis and Impact Considerations of Critical Habitat Designation. U.S. Department of Commerce, NOAA, NMFS.
- NMFS. 2023e. Hawaii Deep-Set Longline Fishery Quarterly and Annual Status Report 2022. Pages 4 *in*. National Marine Fisheries Service, Pacific Islands Regional Office, Honolulu, HI.
- NMFS. 2023f. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Construction, Operation, Maintenance, and Decommissioning of the Empire Wind Offshore Energy Project (Lease OCS-A 0512) and the Connected Action at South Brooklyn Marine Terminal. GARFO-2023-00454. National Marine Fisheries Service Greater Atlantic Regional Fisheries Office.
- NMFS. 2023g. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Construction, Operation, Maintenance, and Decommissioning of the Revolution Wind Offshore Energy Project (Lease OCS-A 0486). GARFO-2022-03532. National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office.
- NMFS. 2023h. Protected Species Management, Conservation of Threatened And Endangered Species Policy Directive 02-110: Guidance on the Endangered Species Act Term "Harass" NMFS Office of Protected Resources.
- NMFS. 2023i. Recovering Threatened and Endangered Species, FY 2021–2022 Report to Congress. National Marine Fisheries Service, Silver Spring, MD.
- NMFS. 2024a. 2023 Annual Report on the National Marine Fisheries Service Sea Turtle Research and Enhancement Permitting Program. Permits and Conservation Division, Office of Protected Resources (OPR).
- NMFS. 2024b. Cruise Report NOAA Ship Gordon Gunter Cruise GU24-02, June – August 2024, Vessel Survey for Abundance and Distribution Summer Research Cruise. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.
- NMFS. 2024c. Endangered Species Act (ESA) Recovery Plan Oceanic Whitetip Shark.
- NMFS. 2024d. Endangered Species Act Recovery Status Review for the Oceanic Whitetip Shark (*Carcharhinus longimanus*). NMFS, editor.
- NMFS. 2024e. Hawaii Deep-set Longline Fishery Quarterly and Annual Status Report 2024. National Marine Fisheries Service, Pacific Islands Regional Office, Honolulu, HI.
- NMFS. 2024f. Reinitiation of the Biological and Conference Opinion on (1) U.S. Navy Hawaii-Southern California Training and Testing, and (2) the National Marine Fisheries Service's Promulgation of Regulations and Issuance of a Letter of Authorization Pursuant to the Marine Mammal Protection Act for the U.S. Navy to "Take" Marine Mammals

- Incidental to Hawaii-Southern California Training and Testing Through December 2025. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.
- NMFS. 2024g. Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0): Underwater and In-Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts. U.S. Dept. of Commerce, NOAA.
- NMFS. 2025a. 5-Year Review of the Oceanic Whitetip Shark (*Carcharhinus longimanus*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 2025b. 2017–2025 North Atlantic Right Whale Unusual Mortality Event. Pages Web page *in*.
- NMFS, and USFWS. 1991. Recovery Plan for U.S. Population of Green Sea Turtle, Washington, D.C.
- NMFS, and USFWS. 1992. Recovery plan for leatherback turtles (*Dermochelys coriacea*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Washington, D.C.
- NMFS, and USFWS. 1993. Recovery plan for hawksbill turtles (*Eretmochelys imbricata*) in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, St. Petersburg, Florida.
- NMFS, and USFWS. 1998. Recovery plan for U.S. Pacific populations of the hawksbill turtle (*Eretmochelys imbricata*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, MD.
- NMFS, and USFWS. 2008. Recovery plan for the northwest Atlantic population of the loggerhead sea turtle (*Caretta caretta*), second revision. National Marine Fisheries Service and United States Fish and Wildlife Service, Silver Spring, Maryland.
- NMFS, and USFWS. 2011. Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), Second Revision. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.
- NMFS, and USFWS. 2015. Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) 5-year Review: Summary and Evaluation. National Marine Fisheries Service and United States Fish and Wildlife Service, Silver Spring, Maryland.
- NMFS, and USFWS. 2020a. Atlantic salmon (*Salmo salar*) 5-Year Review: Summary and Evaluation.
- NMFS, and USFWS. 2020b. Endangered Species Act status review of the leatherback turtle (*Dermochelys coriacea*). Report to the National Marine Fisheries Service Office of Protected Resources and U.S. Fish and Wildlife Service.
- NMFS, and USFWS. 2023. Loggerhead Sea Turtle (*Caretta caretta*) Northwest Atlantic Ocean DPS 5-Year Review: Summary and Evaluation 2023. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland and U.S. Fish and Wildlife Service, Southeast Region, Florida Ecological Services Office, Jacksonville, Florida.
- NMFS, USFWS, SEMARNET, CNANP, and PROFEPA. 2011. Bi-national recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*), second revision. National Marine

- Fisheries Service, United States Fish and Wildlife Service, Secretariat of Environment & Natural Resources, National Commissioner of the Natural Protected Areas, Administrator of the Federal Attorney of Environmental Protection, Silver Spring, Maryland.
- NMFS, U. 2009b. Gulf sturgeon (*Acipenser oxyrinchus desotoi*) 5-year review: Summary and evaluation. U.S. Fish and Wildlife Service and National Marine Fisheries Service.
- NOAA. 2003. Oil and sea turtles: Biology, planning, and response. National Oceanic and Atmospheric Administration, National Ocean Service, Office of Response and Restoration.
- NOAA. 2010. NOAA's oil spill response: Sea turtle strandings and the Deepwater oil spill. N. O. a. A. Administration, editor.
- NOAA. 2014a. 2014 report on the entanglement of marine species in marine debris with an emphasis on species in the United States. National Oceanic and Atmospheric Administration, Marine Debris Program, Silver Spring, Maryland.
- NOAA. 2014b. 2014 Report on the Occurrence and Health Effects of Anthropogenic Debris Ingested by Marine Organisms. NOAA Marine Debris Program. Silver Spring, MD. 19 pp.
- NOAA. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.
- NOAA. 2018a. Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.
- NOAA. 2018b. Status of Puerto Rico's Coral Reefs in the Aftermath of Hurricanes Irma and Maria: Assessment Report Submitted by NOAA to the FEMA Natural and Cultural Resources Recovery Support Function.
- NOAA. 2021. Hurricane Ida. Office of Response and Restoration.
- NOAA. 2023. Crude Oil release: Main Pass, LA. NOAA IncidentNews.
- NOAA. 2024. Flint Hills Dock #5 Oil Spill. Damage Assessment, Remediation, and Restoration Program.
- NOAA. 2025. Impacts of Invasive Lionfish. Pages Webpage *in*. NOAA Fisheries.
- Norem, A. D. 2005. Injury assessment of sea turtles utilizing the neritic zone of the southeastern United States. University of Florida, Gainesville.
- Noriega, R., J. M. Werry, W. Sumpton, D. Mayer, and S. Y. Lee. 2011. Trends in annual CPUE and evidence of sex and size segregation of *Sphyrna lewini*: Management implications in coastal waters of northeastern Australia. *Fisheries Research* 110(3):472-477.
- Normandeau, E., T. Tricas, and A. Gill. 2011. Effects of EMFs from undersea power cables on elasmobranchs and other marine species. U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific Outer Continental Shelf Region, Camarillo, California.
- Norris, K. S., and G. W. Harvey. 1972. A theory for the function of the spermaceti organ of the sperm whale. Pages 393-417 *in* S. R. Galler, editor. *Animal Orientation and Navigation*.
- Notarbartolo-di-Sciara, G., and E. V. Hillyer. 1989. Mobulid rays off eastern Venezuela (*Chondrichthyes*, *Mobulidae*). *Copeia*:607-614.

- Novak, A. J., A. E. Carlson, C. R. Wheeler, G. S. Wippelhauser, and J. A. Sulikowski. 2017. Critical foraging habitat of Atlantic sturgeon based on feeding habits, prey distribution, and movement patterns in the Saco River estuary, Maine. *Transactions of the American Fisheries Society* 146(2):308-317.
- Nowacek, D. P., M. P. Johnson, and P. L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London Series B Biological Sciences* 271(1536):227-231.
- Nowacek, D. P., L. H. Thorne, D. W. Johnston, and P. L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. *Mammal Review* 37(2):81-115.
- NPS. 2024. Padre Island National Seashore, Texas: Sea Turtle Nesting Season. National Park Service, U.S. Department of the Interior.
- NRC. 1990. Sea turtle mortality associated with human activities. Pages 74-117 in N. R. Council, editor. *Decline of the Sea Turtles: Causes and Prevention*. National Academy Press, National Research Council Committee on Sea Turtle Conservation, Washington, D. C.
- NRC. 2003. *Ocean Noise and Marine Mammals*. National Academies Press.
- NRC. 2005. Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects. National Academy of Sciences, Washington, D. C.
- O'Hara, J., and J. R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia* 2:564-567.
- O'Leary, S. J., K. J. Dunton, T. L. King, M. G. Frisk, and D. D. Chapman. 2014. Genetic diversity and effective size of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus* river spawning populations estimated from the microsatellite genotypes of marine-captured juveniles. *Conservation Genetics* 15(5):1173-1181.
- Ocean Conservancy. 2010. *Trash travels: from our hands to the sea, around the globe, and through time*. The Ocean conservancy.
- Oedekoven, C., and L. Thomas. 2022. Effectiveness of Navy lookout teams in detecting cetaceans. Provided to HDR Inc.
- Ohsumi, S., and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. Report of the International Whaling Commission 24:114-126.
- Olafesen, J., and R. Roberts. 1993. Salmon disease: The microbial ecology of fish aquaculture. *Salmon Aquaculture*. Fishing News Books, Oxford:166-186.
- Oleson, E. M., J. Calambokidis, J. Barlow, and J. A. Hildebrand. 2007a. Blue whale visual and acoustic encounter rates in the Southern California Bight. *Marine Mammal Science* 23(3):574-597.
- Oleson, E. M., and coauthors. 2007b. Behavioral context of call production by eastern North Pacific blue whales. *Marine Ecology Progress Series* 330:269-284.
- Oleson, E. M., S. M. Wiggins, and J. A. Hildebrand. 2007c. Temporal separation of blue whale call types on a southern California feeding ground. *Animal Behaviour* 74(4):881-894.
- Oliver, J., and coauthors. 2015. Operationalizing resilience for adaptive coral reef management under global environmental change. *Null*.
- Olla, B. L. 1962. The perception of sound in small hammerhead sharks *Sphyrna lewini*. University of Hawaii, Honolulu, Hawaii.
- Oros, J., O. M. Gonzalez-Diaz, and P. Monagas. 2009. High levels of polychlorinated biphenyls in tissues of Atlantic turtles stranded in the Canary Islands, Spain. *Chemosphere* 74(3):473-478.

- Ozog, J., and E. D. 2025. Mid-Atlantic Marine Mammal Aerial Survey Effort: 2023/2024 Annual Progress Report. Submitted to Naval Facilities Engineering Systems Command Atlantic, Norfolk, Virginia, under Contract N62470-15D-8006, Task Order 20F4031 and Contract N62470-20-0016, Task Order 23F4020, issued to HDR Inc., Virginia Beach, Virginia.
- Pace III, R. M., R. Williams, S. D. Kraus, A. R. Knowlton, and H. M. Pettis. 2021. Cryptic mortality of North Atlantic right whales. *Conservation Science and Practice* 3(2):e346.
- Pace, R., and G. Silber. 2005. Simple analyses of ship and large whale collisions: Does speed kill? Pages 1 *in*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.
- Pace, R. M., P. J. Corkeron, and S. D. Kraus. 2017. State-space mark-recapture estimates reveal a recent decline in abundance of North Atlantic right whales. *Ecology and Evolution*:doi: 10.1002/ece3.3406.
- Pacoureau, N., and coauthors. 2021. Half a century of global decline in oceanic sharks and rays. *Nature* 589(7843):567-571.
- Page-Karjian, A., and coauthors. 2021. Fibropapillomatosis and chelonid alphaherpesvirus 5 infection in kemp's ridley sea turtles (*Lepidochelys kempii*). *Animals* 11(11):3076.
- Pankaew, K., and S. L. Milton. 2018. The effects of extended crawling on the physiology and swim performance of loggerhead and green sea turtle hatchlings. *Journal of Experimental Biology* 221(1):jeb165225.
- Papastavrou, V., S. C. Smith, and H. Whitehead. 1989. Diving behaviour of the sperm whale, *Physeter macrocephalus*, off the Galápagos Islands. *Canadian Journal of Zoology* 67(4):839-846.
- Parker, S. W., W. E. Pine III, B. D. Healy, and J. E. Hines. 2025. Population growth of threatened Gulf Sturgeon may be limited by the frequency of adult episodic mortality events. *Marine and Coastal Fisheries* 17(3):vtaf011.
- Parks, S. E. 2003. Response of North Atlantic right whales (*Eubalaena glacialis*) to playback of calls recorded from surface active groups in both the North and South Atlantic. *Marine Mammal Science* 19(3):563-580.
- Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. 2009 ONR Marine Mammal Program Review, Alexandria, Virginia.
- Parks, S. E. 2011. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research.
- Parks, S. E., and C. W. Clark. 2007. Acoustic communication: Social sounds and the potential impacts of noise. Pages 310-332 *in* S. D. Kraus, and R. M. Rolland, editors. *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, Massachusetts.
- Parks, S. E., C. W. Clark, and P. L. Tyack. 2007a. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Journal of the Acoustical Society of America* 122(6):3725-3731.
- Parks, S. E., D. A. Cusano, S. M. Van Parijs, and D. P. Nowacek. 2019. North Atlantic right whale (*Eubalaena glacialis*) acoustic behavior on the calving grounds. *The Journal of Acoustical Society of America* 146(1):EL15-EL21.
- Parks, S. E., P. K. Hamilton, S. D. Kraus, and P. L. Tyack. 2005. The gunshot sound produced by male North Atlantic right whales (*Eubalaena glacialis*) and its potential function in reproductive advertisement. *Marine Mammal Science* 21(3):458-475.

- Parks, S. E., C. F. Hotchkin, K. A. Cortopassi, and C. W. Clark. 2012a. Characteristics of gunshot sound displays by North Atlantic right whales in the Bay of Fundy. *Journal of the Acoustical Society of America* 131(4):3173-3179.
- Parks, S. E., M. Johnson, D. Nowacek, and P. L. Tyack. 2011a. Individual right whales call louder in increased environmental noise. *Biology Letters* 7(1):33-35.
- Parks, S. E., M. P. Johnson, D. P. Nowacek, and P. L. Tyack. 2012b. Changes in vocal behavior of North Atlantic right whales in increased noise. Pages 4 *in* A. N. Popper, and A. Hawkins, editors. *The Effects of Noise on Aquatic Life*. Springer Science.
- Parks, S. E., D. R. Ketten, J. T. O'malley, and J. Arruda. 2007b. Anatomical predictions of hearing in the North Atlantic right whale. *The Anatomical Record* 290(6):734-44.
- Parks, S. E., and coauthors. 2011b. Sound production behavior of individual North Atlantic right whales: Implications for passive acoustic monitoring. *Endangered Species Research* 15(1):63-76.
- Parks, S. E., and P. L. Tyack. 2005. Sound production by North Atlantic right whales (*Eubalaena glacialis*) in surface active groups. *Journal of the Acoustical Society of America* 117(5):3297-3306.
- Parks, S. E., I. Urazghildiiev, and C. W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. *Journal of the Acoustical Society of America* 125(2):1230-1239.
- Parks, S. E., and S. M. Van Parijs. 2015. Acoustic Behavior of North Atlantic Right Whale (*Eubalaena glacialis*) Mother-Calf Pairs. Office of Naval Research, <https://www.onr.navy.mil/reports/FY15/mbparks.pdf>.
- Patenaude, N. J., and coauthors. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science* 18(2):309-335.
- Patrício, A. R., L. A. Hawkes, J. R. Monsinjon, B. J. Godley, and M. M. Fuentes. 2021. Climate change and marine turtles: recent advances and future directions. *Endangered Species Research* 44:363-395.
- Patterson, B., and G. R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. *Marine Bio-acoustics*, W N Tavolga ed. Pergamon Press Oxford. p.125-145. Proceedings of a Symposium held at the Lerner Marine Laboratory Bimini Bahamas April.
- Patterson, K. L., and coauthors. 2002. The etiology of white pox, a lethal disease of the Caribbean elkhorn coral, *Acropora palmata*. *Proceedings of the National Academy of Sciences* 99(13):8725-8730.
- Payne, P. M., J. R. Nicolas, L. O'brien, and K. D. Powers. 1986. The distribution of the humpback whale, *Megaptera novaeangliae*, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, *Ammodytes americanus*. *Fishery Bulletin* 84(2):271-277.
- Payne, P. M., and coauthors. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in prey abundance. *Fishery Bulletin* 88(4):687-696.
- Payne, R., and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. *Annals of the New York Academy of Sciences* 188(1):110-141.

- Payne, R. S., and S. Mcvay. 1971. Songs of humpback whales. Humpbacks emit sounds in long, predictable patterns ranging over frequencies audible to humans. *Science* 173(3997):585-597.
- Pecl, G. T., and G. D. Jackson. 2008. The potential impacts of climate change on inshore squid: Biology, ecology and fisheries. *Reviews in Fish Biology and Fisheries* 18:373-385.
- Pendleton, R. M., and R. D. Adams. 2021. Long-term trends in juvenile Atlantic sturgeon abundance may signal recovery in the Hudson River, New York, USA. *North American Journal of Fisheries Management* 41(4):1170-1181.
- Peng, C., X. Zhao, and G. Liu. 2015. Noise in the sea and its impacts on marine organisms. *International journal of environmental research and public health* 12(10):12304-12323.
- Peterson, D. L., M. B. Bain, and N. Haley. 2000. Evidence of declining recruitment of Atlantic sturgeon in the Hudson River. *North American Journal of Fisheries Management* 20(1):231-238.
- Pettis, H. M., and P. K. Hamilton. 2015. North Atlantic Right Whale Consortium 2015 Annual Report Card. North Atlantic Right Whale Consortium, <http://www.narwc.org/pdf/2015%20Report%20Card.pdf>.
- Pettis, H. M., and P. K. Hamilton. 2016. North Atlantic Right Whale Consortium 2016 Annual Report Card. North Atlantic Right Whale Consortium, <http://www.narwc.org/pdf/2016%20Report%20Card%20final.pdf>.
- Pettis, H. M., and P. K. Hamilton. 2024. North Atlantic Right Whale Consortium 2023 Annual Report Card.
- Pettis, H. M., R. M. I. Pace, R. S. Schick, and P. K. Hamilton. 2017a. North Atlantic Right Whale Consortium 2017 Annual Report Card. North Atlantic Right Whale Consortium, <http://www.narwc.org/pdf/2017%20Report%20CardFinal.pdf>.
- Pettis, H. M., and coauthors. 2017b. Body condition changes arising from natural factors and fishing gear entanglements in North Atlantic right whales *Eubalaena glacialis*. *Endangered Species Research* 32:237-249.
- Phu, J. L., and P. Palaniappan. 2019. Recaptured wild green turtles (*Chelonia mydas*) with newly documented boat strike injuries in Mabul Island, Sabah, Malaysia. *Chelonian Conservation and Biology: Celebrating 25 Years as the World's Turtle and Tortoise Journal* 18(2):265-272.
- Pimentel, D., R. Zuniga, and D. Morrison. 2004. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics*.
- Pine, W., and S. Martell. 2009. Status of Gulf sturgeon *Acipenser oxyrinchus desotoi* in the Gulf of Mexico: a document prepared for review, discussion, and research planning. Gulf sturgeon annual working group meeting, Cedar Key, Florida.
- Piniak, W. E., D. A. Mann, C. A. Harms, T. T. Jones, and S. A. Eckert. 2016. Hearing in the Juvenile Green Sea Turtle (*Chelonia mydas*): A Comparison of Underwater and Aerial Hearing Using Auditory Evoked Potentials. *PLoS One* 11(10):e0159711.
- Piniak, W. E. D. 2012. Acoustic ecology of sea turtles: Implications for conservation. Duke University.
- Piñón-González, V. M., and A. T. Banaszak. 2018. Effects of Partial Mortality on Growth, Reproduction and Total Lipid Content in the Elkhorn Coral *Acropora palmata*. *Frontiers in Marine Science* 5.
- Pirotta, E., and coauthors. 2022a. From individual responses to population effects: Integrating a decade of multidisciplinary research on blue whales and sonar. *Animal Conservation*.

- Pirotta, E., and coauthors. 2021. Context-dependent variability in the predicted daily energetic costs of disturbance for blue whales. *Conservation Physiology* 9(1).
- Pirotta, E., and coauthors. 2018. Understanding the population consequences of disturbance. *Ecology and Evolution* 8(19):9934-9946.
- Pirotta, E., and coauthors. 2019. Anthropogenic disturbance in a changing environment: modelling lifetime reproductive success to predict the consequences of multiple stressors on a migratory population. *Oikos* 128(9):1340-1357.
- Pirotta, E., and coauthors. 2022b. Understanding the combined effects of multiple stressors: A new perspective on a longstanding challenge. *Science of the Total Environment* 821:153322.
- Pirotta, E., and coauthors. 2024. Decreasing body size is associated with reduced calving probability in critically endangered North Atlantic right whales. *Royal Society Open Science* 11(2):240050.
- Plotkin, P. 2003. Adult migrations and habitat use. Pages 225-241 *in* P. L. Lutz, J. A. Musick, and J. Wyneken, editors. *Biology of sea turtles*, volume II. CRC Press, Boca Raton, Florida.
- Poeta, G., E. Staffieri, A. Acosta, and C. Battisti. 2017. Ecological effects of anthropogenic litter on marine mammals: A global review with a “black-list” of impacted taxa.
- Polyakov, I. V., V. A. Alexeev, U. S. Bhatt, E. I. Polyakova, and X. Zhang. 2009. North Atlantic warming: patterns of long-term trend and multidecadal variability. *Climate Dynamics* 34(3-Feb):439-457.
- Popov, V. V., and coauthors. 2013. Hearing threshold shifts and recovery after noise exposure in beluga whales, *Delphinapterus leucas*. *The Journal of Experimental Biology* 216(9):1587–1596.
- Popper, A., and coauthors. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.
- Popper, A. N. 2005. A review of hearing by sturgeon and lamprey. U.S. Army Corps of Engineers, Portland District.
- Popper, A. N. 2008. Effects of Mid- and High-Frequency Sonars on Fish. Naval Undersea Warfare Center Division, Newport, RI.
- Popper, A. N., and coauthors. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. *The Journal of the Acoustical Society of America* 122(1):623–635.
- Popper, A. N., and M. C. Hastings. 2009. The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology* 75(3):455–489.
- Popper, A. N., and C. R. Schilt. 2009. Hearing and acoustic behavior: Basic and applied considerations. Pages 17-48 *in* J. F. Webb, R. R. Fay, and A. N. Popper, editors. *Fish Bioacoustics*.
- Popper, M. B. H., T. Carlson, and A. N. 2013. Effects of exposure to pile-driving sounds on fish. *Bioacoustics* 17:305-307.
- Porter, J., and coauthors. 2012. Catastrophic Loss of *Acropora palmata* in the Florida Keys: Failure of the ‘Sorcerer’s Apprentice Effect’ to Aid Recovery Following the 2005 Atlantic Hurricane Season. D. Yellowlees, and T. P. Hughes, editors. 12th International Coral Reef Symposium. James Cook University, Cairns, Australia.

- Porter, J. W., J. V. Barton, and C. Torres. 2011. Ecological, Radiological, and Toxicological Effects of Naval Bombardment on the Coral Reefs of Isla de Vieques, Puerto Rico. *Warfare Ecology*:65-122.
- Posada, J. M., G. García-Moliner, and I. N. Oliveras. 1997. Proceedings International Queen Conch Conference *Strombus gigas*. Caribbean Fishery Management Council, San Juan, Puerto Rico.
- Poulakis, G., and J. Seitz. 2004. Recent occurrence of the smalltooth sawfish, *Pristis pectinata* (Elasmobranchiomorphi: Pristidae), in Florida Bay and the Florida Keys, with comments on sawfish ecology. *Florida Scientist* 67(1):27-35.
- Poulakis, G., and coauthors. 2014. Smalltooth Sawfish (*Pristis pectinata*) Research and Outreach: an Interdisciplinary Collaborative Program, Port Charlotte, Florida.
- Poulakis, G. R., and R. D. Grubbs. 2019. Biology and ecology of sawfishes: global status of research and future outlook. *Endangered Species Research* 39:77-90.
- Poulakis, G. R., P. W. Stevens, A. A. Timmers, T. R. Wiley, and C. A. Simpfendorfer. 2011. Abiotic affinities and spatiotemporal distribution of the endangered smalltooth sawfish, *Pristis pectinata*, in a south-western Florida nursery. *Marine and Freshwater Research* 62(10):1165.
- Powers, S. P., F. J. Hernandez, R. H. Condon, J. M. Drymon, and C. M. Free. 2013. Novel pathways for injury from offshore oil spills: Direct, sublethal and indirect effects of the *Deepwater Horizon* oil spill on pelagic *Sargassum* communities. *PLoS One* 8(9):e74802.
- Precht, W. F., B. E. Gintert, M. L. Robbart, R. Fura, and R. van Woesik. 2016. Unprecedented Disease-Related Coral Mortality in Southeastern Florida. *Scientific Reports* 6:31374.
- Price, C. S., and coauthors. 2017. Protected Species Marine Aquaculture Interactions. NOAA Technical Memorandum NOS NCCOS 211.
- Price, C. S., and J. A. Morris. 2013. Marine cage culture and the environment: Twenty-first century science informing a sustainable industry.
- Price, E. R., and coauthors. 2004. Size, growth, and reproductive output of adult female leatherback turtles *Dermochelys coriacea*. *Endangered Species Research* 5:1-8.
- Prieto, R., D. Janiger, M. A. Silva, G. T. Waring, and J. M. Goncalves. 2012. The forgotten whale: a bibliometric analysis and literature review of the North Atlantic sei whale *Balaenoptera borealis*. *Mammal Review* 42(3):235.
- Prohaska, B. K., and coauthors. 2018. Physiological stress in the smalltooth sawfish: effects of ontogeny, capture method, and habitat quality. *Endangered Species Research* 36:121-135.
- Pughiuc, D. 2010. Invasive species: Ballast water battles. *Seaways*.
- Putman, N. F., P. Verley, C. S. Endres, and K. J. Lohmann. 2015. Magnetic navigation behavior and the oceanic ecology of young loggerhead sea turtles. *Journal of Experimental Biology* 218(7):1044–1050.
- Pysanczyn, J. W., and coauthors. 2023. The role of acoustics within the sensory landscape of coral larval settlement. *Frontiers in Marine Science* 10:1111599.
- Queiroz, N., and coauthors. 2019. Global spatial risk assessment of sharks under the footprint of fisheries. *Nature* 572(7770):461-466.
- Quintana-Rizzo, E., and coauthors. 2021. Residency, demographics, and movement patterns of North Atlantic right whales *Eubalaena glacialis* in an offshore wind energy development area in southern New England, USA. *Endangered Species Research* 45:251-268.
- Raaymakers, S. 2003. The GEF/UNDP/IMO global ballast water management programme integrating science, shipping and society to save our seas. *Proceedings of the Institute of*

- Marine Engineering, Science and Technology Part B: Journal of Design and Operations (B4):2-10.
- Raaymakers, S., and R. Hilliard. 2002. Harmful aquatic organisms in ships' ballast water - Ballast water risk assessment, 1726-5886, Istanbul, Turkey.
- Rabalais, N. N., R. E. Turner, and D. Scavia. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. *BioScience* 52(2):129-142.
- Rambahiniarison, J. M., and coauthors. 2018. Life history, growth, and reproductive biology of four mobulid species in the Bohol Sea, Philippines. *Frontiers in Marine Science* 5:269.
- Ramp, C., M. Bérubé, W. Hagen, and R. Sears. 2006. Survival of adult blue whales *Balaenoptera musculus* in the Gulf of St. Lawrence, Canada. *Marine Ecology Progress Series* 319:287-295.
- Ramp, C., R. Sears, and Q. St Lambert. 2013. Distribution, densities, and annual occurrence of individual blue whales (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada from 1980-2008. Fisheries and Oceans Canada, Science.
- Randall, J. E. 1964. Contributions to the biology of the queen conch, *Strombus gigas*.
- Randall, M., and K. Sulak. 2012. Evidence of autumn spawning in Suwannee River Gulf sturgeon, *Acipenser oxyrinchus desotoi* (Vladykov, 1955). *Journal of Applied Ichthyology* 28(4):489-495.
- Rankin, S., D. Ljungblad, C. Clark, and H. Kato. 2005. Vocalisations of Antarctic blue whales, *Balaenoptera musculus intermedia*, recorded during the 2001/2002 and 2002/2003 IWC/SOWER circumpolar cruises, Area V, Antarctica. *Journal of Cetacean Research and Management* 7(1):13-20.
- Rappucci, G., and coauthors. 2023. Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS): Marine Mammals, Volume 1: Report. US Department of the Interior, Bureau of Ocean Energy Management, New Orleans (LA).
- Ray, G. L. 2005. Invasive Marine and Estuarine Animals of the Gulf of Mexico. US Army Engineer Research and Development Center.
- Read, A. J., P. Drinker, and S. Northridge. 2006. Bycatch of marine mammals in US and global fisheries. *Conservation Biology* 20(1):163-169.
- Record, N. R., and coauthors. 2019. Rapid climate-driven circulation changes threaten conservation of endangered North Atlantic right whales. *Oceanography* 32(2):162-169.
- Redfern, J. V., and coauthors. 2019. Evaluating stakeholder-derived strategies to reduce the risk of ships striking whales. *Diversity and Distributions* 25(10):1575-1585.
- Reed, J., and coauthors. 2014. Characterization of the Mesophotic Benthic Habitat and Fish Assemblages from ROV Dives on Pulley Ridge and Tortugas during 2014 R/V Walton Smith Cruise.
- Reed, J., L. New, P. Corkeron, and R. Harcourt. 2022. Multi-event modeling of true reproductive states of individual female right whales provides new insights into their decline. *Frontiers in Marine Science* 9:994481.
- Reed, J., L. New, P. Corkeron, and R. Harcourt. 2024. Disentangling the influence of entanglement on recruitment in North Atlantic right whales. *Proceedings of the Royal Society B* 291(2018):20240314.
- Reed, J. K., and coauthors. 2019. Pulley ridge, gulf of Mexico, USA. Mesophotic coral ecosystems:57-69.

- Reeves, R. R. 2020. Overview of catch history, historic abundance and distribution of right whales in the western North Atlantic and in Cintra Bay, West Africa. *J. Cetacean Res. Manage.*:187-192.
- Reeves, R. R., J. N. Lund, T. D. Smith, and E. A. Josephson. 2011. Insights from whaling logbooks on whales, dolphins, and whaling in the Gulf of Mexico. *Gulf of Mexico Science* 29(1):41-67.
- Reeves, R. R., G. K. Silber, and P. M. Payne. 1998. Draft Recovery Plan for the Fin Whale *Balaenoptera physalus* and Sei Whale *Balaenoptera borealis*. Silver Spring, MD.
- Reeves, R. R., and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. *Canadian field-naturalist*. Ottawa ON 111(2):293-307.
- Reid, K. A., D. Margaritoulis, and J. R. Speakman. 2009. Incubation temperature and energy expenditure during development in loggerhead sea turtle embryos. *Journal of Experimental Marine Biology and Ecology* 378(1-2):62-68.
- Reilly, S. B., and coauthors. 2013. *Balaenoptera physalus*. The IUCN Red List of Threatened Species. The IUCN Red List of Threatened Species 2013:e.T2478A44210520.
- Reina, R. D., P. a. Mayor, J. R. Spotila, R. Piedra, and F. V. Paladino. 2002. Nesting ecology of the leatherback turtle, *Dermochelys coriacea*, at Parque Nacional Marino Las Baulas, Costa Rica: 1988-1989 to 1999-2000. *Copeia* 2002(3):653-664.
- Reine, K., and coauthors. 2014. Assessing impacts of navigation dredging on Atlantic sturgeon (*Acipenser oxyrinchus*). ENGINEER RESEARCH AND DEVELOPMENT CENTER VICKSBURG MS ENVIRONMENTAL LAB.
- Renan de Deus Santos, M., and coauthors. 2017. Stress Response of Juvenile Green Sea Turtles (*Chelonia mydas*) with Different Fibropapillomatosis Scores. *Journal of Wildlife Diseases*.
- Rendell, L., S. L. Mesnick, M. L. Dalebout, J. Burtenshaw, and H. Whitehead. 2012. Can genetic differences explain vocal dialect variation in sperm whales, *Physeter macrocephalus*? *Behavior Genetics* 42(2):332-43.
- Rendell, L., and H. Whitehead. 2004. Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. *Animal Behaviour* 67(5):865-874.
- Reyff, J. A. 2003. Underwater sound levels associated with construction of the Benicia-Martinez Bridge. Illingworth & Rodkin, Inc.
- Reyff, J. A. 2008. Underwater sound pressure levels associated with marine pile driving: assessment of impacts and evaluation of control measures. *Journal of Transportation Research Board* CD 11-S:481-490.
- Reyff, J. A. 2012. Underwater sounds from unattenuated and attenuated marine pile driving. Pages 439-444 in A. N. Popper, and A. D. Hawkins, editors. *The effects of noise on aquatic life*. Springer Science + Business Media, LLC, New York, NY.
- Rice, A. N., K. J. Palmer, J. T. Tielens, C. A. Muirhead, and C. W. Clark. 2014. Potential Bryde's whale (*Balaenoptera edeni*) calls recorded in the northern Gulf of Mexico. *Journal of the Acoustical Society of America* 135(5):3066-3076.
- Rice, J., and S. Harley. 2012. Stock assessment of oceanic whitetip sharks in the western and central Pacific Ocean. Western and Central Pacific Fisheries Commission Scientific Committee Eighth Regular Session. WCPFC-SC8-2012/SA-WP-06 Rev 1., 53. Pages 53 in.
- Richardson, A. J., R. J. Matear, and A. Lenton. 2017. Potential impacts on zooplankton of seismic surveys. CSIRO, Australia.

- Richardson, W. J. 1995. Marine mammal hearing. Pages 205-240 in C. R. W. J. G. J. Richardson, C. I. Malme, and D. H. Thomson, editors. *Marine Mammals and Noise*. Academic Press, San Diego, California.
- Richardson, W. J., M. A. Fraker, B. Wursig, and R. S. Wells. 1985. Behavior of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: Reactions to industrial activities. *Biological Conservation* 32(3):195-230.
- Richardson, W. J., C. R. Greene, C. I. Malme, and D. H. Thomson. 1995a. *Marine Mammals and Noise*. Academic Press, Inc., San Diego, California.
- Richardson, W. J., and coauthors. 1995b. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska - 1991 and 1994 phases: Sound propagation and whale responses to playbacks of icebreaker noise. U.S. Department of the Interior, Minerals Management Service.
- Richmond, D. R., J. T. Yelverton, and E. R. Fletcher. 1973. Far-field underwater-blast injuries produced by small charges. Lovelace Foundation for Medical Education and Research.
- Richter, C., S. Dawson, and E. Slooten. 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. *Marine Mammal Science* 22(1):46-63.
- Richter, C. F., S. M. Dawson, and E. Slooten. 2003. Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. *Science for Conservation* 219.
- Rider, M. J., and coauthors. 2024. Where the leatherbacks roam: movement behavior analyses reveal novel foraging locations along the Northwest Atlantic shelf. *Frontiers in Marine Science* 11:1325139.
- Ridgway, S. H., E. G. Wever, J. G. McCormick, J. Palin, and J. H. Anderson. 1969. Hearing in the giant sea turtle, *Chelonoa mydas*. *Proceedings of the National Academies of Science* 64.
- Rieth, T. M., T. L. Hunt, C. Lipo, and J. M. Wilmshurst. 2011. The 13th century polynesian colonization of Hawaii Island. *Journal of Archaeological Science* 28:2740–2749.
- Rigby, C., and coauthors. 2019a. Oceanic whitetip shark (*Carcharhinus longimanus*): Supplementary Information for *Carcharhinus longimanus*. The IUCN Red List of Threatened Species: *Carcharhinus longimanus*—published in 2019:12.
- Rigby, C., and coauthors. 2019b. *Sphyrna lewini*. The IUCN red list of threatened species 2019.
- Ritson-Williams, R., V. J. Paul, S. N. Arnold, and R. S. Steneck. 2010. Larval settlement preferences and post-settlement survival of the threatened Caribbean corals *Acropora palmata* and *A. cervicornis*. *Coral Reefs* 29(1):71-81.
- Rivers, J. A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. *Marine Mammal Science* 13(2):186-195.
- Roberts, J. J., T. M. Yack, and P. N. Halpin. 2023. Marine mammal density models for the US Navy Atlantic Fleet Training and Testing (AFTT) study area for the Phase IV Navy Marine Species Density Database (NMSDD), Durham, NC.
- Roberts, M. A., T. S. Schwartz, and S. A. Karl. 2004. Global population genetic structure and male-mediated gene flow in the green sea turtle (*Chelonia mydas*): analysis of microsatellite loci. *Genetics* 166(4):1857-1870.
- Robinson, R. A., and coauthors. 2005. *Climate change and migratory species*. Defra Research, British Trust for Ornithology, Norfolk, U.K. .

- Rockwood, R. C., J. Adams, G. Silber, and J. Jahncke. 2020. Estimating effectiveness of speed reduction measures for decreasing whale-strike mortality in a high-risk region. *Endangered Species Research* 43:145-166.
- Rockwood, R. C., J. D. Adams, S. Hastings, J. Morten, and J. Jahncke. 2021. Modeling Whale Deaths From Vessel Strikes to Reduce the Risk of Fatality to Endangered Whales. *Frontiers in Marine Science*:919.
- Rockwood, R. C., J. Calambokidis, and J. Jahncke. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. *PLoS One* 12(8):e0183052.
- Rogers, C. S., and V. H. Garrison. 2001. Ten years after the crime: Lasting effects of damage from a cruise ship anchor on a coral reef in St. John, U.S. Virgin Islands. *Bulletin of Marine Science* 69(2):793-803.
- Rogers, C. S., T. H. Suchanek, and F. A. Pecora. 1982. Effects of Hurricanes David and Frederic (1979) on shallow *Acropora palmata* reef communities: St. Croix, U.S. Virgin Islands. *Bulletin of Marine Science* 32(2):532-548.
- Rohner, C., and coauthors. 2013. Trends in sightings and environmental influences on a coastal aggregation of manta rays and whale sharks. *Marine Ecology Progress Series* 482:153-168.
- Rolland, R. M., and coauthors. 2017. Fecal glucocorticoids and anthropogenic injury and mortality in North Atlantic right whales *Eubalaena glacialis*. *Endangered Species Research* 34:417-429.
- Rolland, R. M., and coauthors. 2012. Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society of London Series B Biological Sciences* 279(1737):2363-2368.
- Rolland, R. M., and coauthors. 2016. Health of North Atlantic right whales *Eubalaena glacialis* over three decades: From individual health to demographic and population health trends. *Marine Ecology Progress Series* 542:265-282.
- Romero, L. M., and M. Wikelski. 2001. Corticosterone levels predict survival probabilities of Galapagos marine iguanas during El Nino events. *Proceedings of the National Academy of Sciences* 98:7366-7370.
- Rosel, P. E., Peter Corkeron, Laura Engleby, Deborah Epperson, Keith D. Mullin, Melissa S. Soldevilla, Barbara L. Taylor. 2016. Status Review of Bryde's Whales (*Balaenoptera edeni*) in the Gulf of Mexico under the Endangered Species Act. NMFS Southeast Fisheries Science Center, NOAA Technical Memorandum NMFS-SEFSC-692, Lafayette, Louisiana.
- Rosel, P. E., and L. A. Wilcox. 2014. Genetic evidence reveals a unique lineage of Bryde's whales in the northern Gulf of Mexico. *Endangered Species Research* 25(1):19-34.
- Rosel, P. E., L. A. Wilcox, T. K. Yamada, and K. D. Mullin. 2021. A new species of baleen whale (*Balaenoptera*) from the Gulf of Mexico, with a review of its geographic distribution. *Marine Mammal Science* 37(2):577-610.
- Rosenbaum, H. C., M. G. Egan, P. J. Clapham, R. L. Brownell Jr., and R. Desalle. 1997. An effective method for isolating DNA from historical specimens of baleen. *Molecular Ecology* 6(7):677-681.
- Rosenbaum, H. C., and coauthors. 2000. Utility of North Atlantic right whale museum specimens for assessing changes in genetic diversity. *Conservation Biology* 14(6):1837-1842.

- Rosenfeld, J. S. 2014. 50/500 or 100/1000? Reconciling short-and long-term recovery targets and MVPs. *Biological Conservation* 176:287-288.
- Rosenthal, H., and D. Alderdice. 1976. Sublethal effects of environmental stressors, natural and pollutional, on marine fish eggs and larvae. *Journal*.
- Ross, D. 2013. *Mechanics of underwater noise*. Elsevier.
- Ross, S. T., and coauthors. 2009. Estuarine and coastal habitat use of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the north-central Gulf of Mexico. *Estuaries and Coasts* 32(2):360-374.
- Rothermel, E. R., and coauthors. 2020. Comparative migration ecology of striped bass and Atlantic sturgeon in the US Southern mid-Atlantic bight flyway. *PLoS One* 15(6):e0234442.
- Rubin, R., K. Kumli, and G. Chilcott. 2008. Dive characteristics and movement patterns of acoustic and satellite-tagged manta rays (*Manta birostris*) in the Revillagigedos Islands of Mexico. Joint Meeting of Ichthyologists and Herpetologists. Montreal, Canada.
- Ruck, C. L. 2016. Global genetic connectivity and diversity in a shark of high conservation concern, the oceanic whitetip, *Carcharhinus longimanus*. Nova Southeastern University, Fort Lauderdale, Florida.
- Ruck, C. L., M. S. Shivji, R. W. Jabado, and A. M. Bernard. 2024. Cross ocean-basin population genetic dynamics in a pelagic top predator of high conservation concern, the oceanic whitetip shark, *Carcharhinus longimanus*. *Conservation Genetics* 25(3):677-695.
- Rudd, M. B., R. N. Ahrens, W. E. Pine III, and S. K. Bolden. 2014. Empirical, spatially explicit natural mortality and movement rate estimates for the threatened Gulf Sturgeon (*Acipenser oxyrinchus desotoi*). *Canadian Journal of Fisheries and Aquatic Sciences* 71(9):1407-1417.
- Ruelle, R., and K. D. Keenlyne. 1993. Contaminants in Missouri River pallid sturgeon. *Bulletin of Environmental Contamination and Toxicology* 50(6):898-906.
- Rulifson, R. A., and coauthors. 2020. Seasonal presence of Atlantic Sturgeon and sharks at Cape Hatteras, a large continental shelf constriction to coastal migration. *Marine and Coastal Fisheries* 12(5):308-321.
- Sadovy, Y., and A.-M. Eklund. 1999. NOAA Technical Report NMFS 146, Synopsis of Biological Data on the Nassau Grouper, *Epinephelus striatus*, (Block, 1972), and the Jewfish, *E. itajara* (Lichtenstein, 1822). National Marine Fisheries Service,, 157, Seattle, WA.
- Sahoo, G., R. K. Sahoo, and P. Mohanty-Hejmadi. 1996. Distribution of heavy metals in the eggs and hatchlings of olive ridley sea turtles, *Lepidochelys olivacea*, from Gahirmatha, Orissa. *Indian Journal of Marine Sciences* 25(4):371-372.
- Salas, A. K., A. M. Capuano, C. A. Harms, W. E. Piniak, and T. A. Mooney. 2023a. Temporary noise-induced underwater hearing loss in an aquatic turtle (*Trachemys scripta elegans*). *The Journal of Acoustical Society of America* 154(2):1003-1017.
- Salas, A. K., A. M. Capuano, C. A. Harms, W. E. D. Piniak, and T. A. Mooney. 2023b. Frequency-dependent temporary threshold shifts in the Eastern Painted Turtle (*Chrysemys picta picta*). In Progress.
- Salisbury, D. P., C. W. Clark, and A. N. Rice. 2016. Right whale occurrence in the coastal waters of Virginia, U.S.A.: Endangered species presence in a rapidly developing energy market. *Marine Mammal Science* 32(2):508-519.

- Salmon, M., T. T. Jones, and K. W. Horch. 2004. Ontogeny of diving and feeding behavior in juvenile sea turtles: Leatherback sea turtles (*Dermochelys coriacea* L.) and green sea turtles (*Chelonia mydas* L.) in the Florida Current. *Journal of Herpetology* 38(1):36-43.
- Samaran, F., C. Guinet, O. Adam, J. F. Motsch, and Y. Cansi. 2010. Source level estimation of two blue whale subspecies in southwestern Indian Ocean. *Journal of the Acoustical Society of America* 127(6):3800-3808.
- Sanchez-Rubio, G., H. Perry, J. S. Franks, and D. R. Johnson. 2018. Occurrence of pelagic Sargassum in waters of the US Gulf of Mexico in response to weather-related hydrographic regimes associated with decadal and interannual variability in global climate. *Fishery Bulletin* 116(1).
- Sanderson, B. L., K. A. Barnas, and A. M. W. Rub. 2009. Nonindigenous Species of the Pacific Northwest: An Overlooked Risk to Endangered Salmon? *BioScience* 59(3):245-256.
- Santidrián Tomillo, P., and coauthors. 2012. Climate driven egg and hatchling mortality threatens survival of Eastern Pacific leatherback turtles. *PLoS One* 7(5):e37602.
- Sapolsky, R. M., L. M. Romero, and A. U. Munck. 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. *Endocrine Reviews* 21(1):55-89.
- Sapp, A. 2010. Influence of Small Vessel Operation and Propulsion System on Loggerhead Sea Turtle Injuries. Georgia Institute of Technology, GA.
- Schaeff, C. M., and coauthors. 1997. Comparison of genetic variability of North and South Atlantic right whales (*Eubalaena*), using DNA fingerprinting. *Canadian Journal of Zoology* 75(7):1073-1080.
- Scherer, L., I. Gürdal, and P. M. v. Bodegom. 2022. Characterization factors for ocean acidification impacts on marine biodiversity. *Journal of Industrial Ecology* 26(6).
- Schlaepfer, M. A., D. F. Sax, and J. D. Olden. 2011. The potential conservation value of non-native species. *Conservation Biology* 25(3):428-437.
- Schleimer, A., and coauthors. 2019. Decline in abundance and apparent survival rates of fin whales (*Balaenoptera physalus*) in the northern Gulf of St. Lawrence. *Ecology and Evolution* 9(7):4231-4244.
- Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. *The Journal of Acoustical Society of America* 107(6):3496-3508.
- Schmid, J. R. 1998. Marine turtle populations on the west-central coast of Florida: Results of tagging studies at the Cedar Keys, Florida, 1986-1995. *Fishery Bulletin* 96(3):589-602.
- Schofield, G., and coauthors. 2009. Microhabitat selection by sea turtles in a dynamic thermal marine environment. *Journal of Animal Ecology*:14-21.
- Scholik, A. R., and H. Y. Yan. 2001. Effects of underwater noise on auditory sensitivity of a cyprinid fish. *Hearing Research* 152(2-Jan):17-24.
- Scholik, A. R., and H. Y. Yan. 2002. The effects of noise on the auditory sensitivity of the bluegill sunfish, *Lepomis macrochirus*. *Comparative Biochemistry and Physiology A Molecular and Integrative Physiology* 133(1):43-52.
- Scholz, N. L., and coauthors. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha*). *Canadian Journal of Fisheries and Aquatic Sciences* 57(9):1911-1918.

- Schuhmacher, H., and H. Zibrowius. 1985. What is hermatypic? A redefinition of ecological groups in corals and other organisms. *Coral Reefs* 4(1):1-9.
- Schulze-Haugen, M., and N. E. Kohler. 2003. Guide to Sharks, Tunas, & Billfishes of the U.S. Atlantic and Gulf of Mexico. RI Sea Grant and National Marine Fisheries Service.
- Schuyler, Q. A. 2014. Ingestion of marine debris by sea turtles. Doctoral dissertation. The University of Queensland.
- Schuyler, Q. A., and coauthors. 2016. Risk analysis reveals global hotspots for marine debris ingestion by sea turtles. *Global Change Biology* 22(2):567-576.
- Secor, D. H. 2002. Atlantic sturgeon fisheries and stock abundances during the late nineteenth century. Pages 89-100 *in* American Fisheries Society Symposium. American Fisheries Society.
- Secor, D. H., and E. J. Niklitschek. 2001. Hypoxia and sturgeons. University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Technical Report Series No. TS-314-01-CBL, Solomons, Maryland.
- Secor, D. H., and coauthors. 2022. Atlantic Sturgeon Status and Movement Ecology in an Extremely Small Spawning Habitat: The Nanticoke River-Marshyhope Creek, Chesapeake Bay. *Reviews in Fisheries Science & Aquaculture* 30(2):195-214.
- Seitz, J., and G. R. Poulakis. 2002. Recent occurrence of sawfishes (Elasmobranchiomorphi: Pristidae) along the southwest coast of Florida (USA). *Florida Scientist* 65(4):256-266.
- Seki, T., T. Taniuchi, H. Nakano, and M. Shimizu. 1998. Age, Growth and Reproduction of the Oceanic Whitetip Shark from the Pacific Ocean. *Fisheries science* 64(1):14-20.
- Seminoff, J. A., and coauthors. 2015. Status review of the green turtle (*Chelonia mydas*) under the Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.
- Shamblin, B. M., and coauthors. 2014. Geographic patterns of genetic variation in a broadly distributed marine vertebrate: New insights into loggerhead turtle stock structure from expanded mitochondrial DNA sequences. *PLoS One* 9(1):e85956.
- Shamblin, B. M., and coauthors. 2017. Improved female abundance and reproductive parameter estimates through subpopulation-scale genetic capture-recapture of loggerhead turtles. *Marine Biology* 164(6):138.
- Shamblin, B. M., and coauthors. 2016. Mexican origins for the Texas green turtle foraging aggregation: A cautionary tale of incomplete baselines and poor marker resolution. *Journal of Experimental Marine Biology and Ecology* 488:111-120.
- Shannon, L. H. 2017. Warfare Ecology on an Underwater Demolition Range: Acoustic Observations of Marine Life and Shallow Water Detonations in Hawaii. University of Hawai'i at Manoa.
- Shaver, D. J., and coauthors. 2016. Migratory corridors of adult female Kemp's ridley turtles in the Gulf of Mexico. *Biological Conservation* 194:158-167.
- Shillinger, G. L., and coauthors. 2011. Vertical and horizontal preferences of post-nesting leatherback turtles in the South Pacific Ocean. *Marine Ecology Progress Series* 422:275-289.
- Shinn, E. 1963. Spur and groove formation on the Florida Reef Tract. *Journal of Sedimentary Petrology* 33(2):291-303.
- Silber, G., J. Slutsky, and S. Bettridge. 2010. Hydrodynamics of a ship/whale collision. *Journal of Experimental Marine Biology and Ecology* 391:19-Oct.

- Silber, G. K., D. W. Weller, R. R. Reeves, J. D. Adams, and T. J. Moore. 2021. Co-occurrence of gray whales and vessel traffic in the North Pacific Ocean. *Endangered Species Research* 44:177-201.
- Silve, L. D., P. Wensveen, F. Visser, and C. Cure. 2016. Naval sonar disrupts foraging in humpback whales. *Marine Ecology Progress Series* 562:211-220.
- Simeone, C. A., F. M. Gulland, T. Norris, and T. K. Rowles. 2015. A systematic review of changes in marine mammal health in North America, 1972-2012: the need for a novel integrated approach. *PLoS One* 10(11):e0142105.
- Simmonds, M. P., and W. J. Elliott. 2009. Climate change and cetaceans: Concerns and recent developments. *Journal of the Marine Biological Association of the United Kingdom* 89(1):203-210.
- Simmonds, M. P., and S. J. Isaac. 2007. The impacts of climate change on marine mammals: Early signs of significant problems. *Oryx* 41(1):19-26.
- Simpfendorfer, C. 2002. Smalltooth sawfish: the USA's first endangered elasmobranch. *Endangered Species UPDATE* 19(3):45-49.
- Simpfendorfer, C., G. Poulakis, P. O'Donnell, and T. Wiley. 2008. Growth rates of juvenile smalltooth sawfish *Pristis pectinata* Latham in the western Atlantic. *Journal of Fish Biology* 72(3):711-723.
- Simpfendorfer, C. A. 2000. Predicting population recovery rates for endangered western Atlantic sawfishes using demographic analysis. *Environmental Biology of Fishes* 58(4):371-377.
- Simpfendorfer, C. A. 2005. Threatened fishes of the world: *Pristis pectinata* Latham, 1794 (Pristidae). *Environmental Biology of Fishes* 73(1):20-20.
- Simpfendorfer, C. A., and T. R. Wiley. 2004. Determination of the distribution of Florida's remnant sawfish population, and identification of areas critical to their conservation. Mote Marine Laboratory Technical Report.
- Simpfendorfer, C. A., T. R. Wiley, and B. G. Yeiser. 2010. Improving conservation planning for an endangered sawfish using data from acoustic telemetry. *Biological Conservation* 143(6):1460-1469.
- Simpfendorfer, C. A., and coauthors. 2011. Environmental influences on the spatial ecology of juvenile smalltooth sawfish (*Pristis pectinata*): results from acoustic monitoring. *PLoS One* 6(2):e16918.
- Singel, K., A. Foley, and R. Bailey. 2007. Navigating Florida's waterways: Boat-related strandings of marine turtles in Florida. *Proceedings 27th Annual Symposium on Sea Turtle Biology and Conservation*, Myrtle Beach, SC. International Sea Turtle Society.
- Sirovic, A., J. A. Hildebrand, and S. M. Wiggins. 2007. Blue and fin whale call source levels and propagation range in the Southern Ocean. *Journal of the Acoustical Society of America* 122(2):1208-1215.
- Sivle, L., and coauthors. 2012. Changes in dive behavior during naval sonar exposure in killer whales, long-finned pilot whales, and sperm whales. *Frontiers in Physiology* 3(400).
- Sivle, L. D., and coauthors. 2015. Severity of expert-identified behavioural responses of humpback whale, minke whale, and northern bottlenose whale to naval sonar. *Aquatic Mammals*, 41(4), 469–502. .
- Sivle, L. D., and coauthors. 2016. Naval sonar disrupts foraging in humpback whales. *Marine Ecology Progress Series* 562:211-220.
- Slabbekoorn, H., and coauthors. 2019. Population-level consequences of seismic surveys on fishes: An interdisciplinary challenge. *Fish and Fisheries* 20(4):653-685.

- Smith, C. E., and coauthors. 2016. Assessment of known impacts of unmanned aerial systems (UAS) on marine mammals: data gaps and recommendations for researchers in the United States¹. *Journal of Unmanned Vehicle Systems* 4(1):31-44.
- Smith, H. A., and coauthors. 2023. Drivers of coral mortality in non-acute disturbance periods. *Marine Ecology Progress Series* 717:37-50.
- Smith, M. E., and coauthors. 2022a. Physical effects of sound exposure from underwater explosions on Pacific mackerel (*Scomber japonicus*): Effects on the inner ear. *The Journal of the Acoustical Society of America* 152(2):733.
- Smith, M. E., and coauthors. 2022b. Physical effects of sound exposure from underwater explosions on Pacific mackerel (*Scomber japonicus*): Effects on the inner ear. *The Journal of Acoustical Society of America* 152(2):733-744.
- Smith, M. E., A. B. Coffin, D. L. Miller, and A. N. Popper. 2006. Anatomical and functional recovery of the goldfish (*Carassius auratus*) ear following noise exposure. *Journal of Experimental Biology* 209(21):4193-4202.
- Smith, M. E., A. S. Kane, and A. N. Popper. 2004. Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). *Journal of Experimental Biology* 207(3):427-435.
- Smith, S. H., and D. E. Marx Jr. 2016. De-facto marine protection from a Navy bombing range: Farallon De Medinilla, Mariana Archipelago, 1997 to 2012. *Marine Pollution Bulletin* 102(1):187-198.
- Smith, T. B. 2013. United States Virgin Island's response to the proposed listing or change in status of seven Caribbean coral species under the U.S. Endangered Species Act. University of the Virgin Islands, Center for Marine and Environmental Studies.
- Smith, T. B., and coauthors. 2010. Benthic structure and cryptic mortality in a Caribbean mesophotic coral reef bank system, the Hind Bank Marine Conservation District, US Virgin Islands. *Coral Reefs* 29(2):289-308.
- Smith, T. I. 1985. The fishery, biology, and management of Atlantic sturgeon, *Acipenser oxyrinchus*, in North America. *Environmental Biology of Fishes* 14(1):61-72.
- Smith, T. I. J., and J. P. Clugston. 1997. Status and management of Atlantic sturgeon, *Acipenser oxyrinchus*, in North America. *Environmental Biology of Fishes* 48(1-4):335-346.
- Smultea, M. A., J. R. Mobley, D. Fertl, and G. L. Fulling. 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research* 20:75-80.
- Smultea, M. A., J. R. Mobley Jr., and K. Lomac-Macnair. 2009. Aerial survey monitoring for marine mammals and sea turtles in conjunction with US Navy major training events off San Diego, California, 15-21 October and 15-18 November 2008, final report. Naval Facilities Engineering Command Pacific, EV2 Environmental Planning, Pearl Harbor, Hawaii.
- Smultea, M. A., F. C. Robertson, and D. Fertl. 2022. Blue Whale (*Balaenoptera musculus*) Mother-Calf Pair Behavioral Response to Vessel in the Southern California Bight. *Aquatic Mammals* 48(6):690-692.
- Sohn, R. A., F. Vernon, J. A. Hildebrand, and S. C. Webb. 2000. Field measurements of sonic boom penetration into the ocean. *Journal of the Acoustical Society of America* 107(6):3073-3083.
- Soldevilla, M. S., A. J. Debich, L. P. Garrison, J. A. Hildebrand, and S. M. Wiggins. 2022. Rice's whales in the northwestern Gulf of Mexico: call variation and occurrence beyond the known core habitat. *Endangered Species Research* 48:155-174.

- Soldevilla, M. S., and coauthors. 2017. Spatial distribution and dive behavior of Gulf of Mexico Bryde's whales: potential risk of vessel strikes and fisheries interactions. *Endangered Species Research* 32:533-550.
- Soldevilla, M. S., A. N. Rice, C. W. Clark, and L. P. Garrison. 2014. Passive acoustic monitoring on the North Atlantic right whale calving grounds. *Endangered Species Research* 25(2):115-140.
- Solé, M., and coauthors. 2023. Marine invertebrates and noise. *Frontiers in Marine Science* 10:1129057.
- Soong, K., and J. C. Lang. 1992. Reproductive integration in reef corals. *Biological Bulletin* 183(3):418-431.
- Sørensen, P. M., and coauthors. 2023. Anthropogenic noise impairs cooperation in bottlenose dolphins. *Current Biology* 33:1-6.
- Soto-Santiago, F. J., and coauthors. 2017. Comparative demography of two common scleractinian corals: *Orbicella annularis* and *Porites astreoides*. *PeerJ* 5:e3906.
- Sousa-Lima, R. S., and C. W. Clark. 2008. Modeling the effect of boat traffic on the fluctuation of humpback whale singing activity in the Abrolhos National Marine Park, Brazil. *Canadian Acoustics* 36(1):174-181.
- Southall, B., and coauthors. 2007. Aquatic mammals marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33(4):122.
- Southall, B., and coauthors. 2013. Measuring cetacean responses to military sonar: Behavioral response studies in southern California (SOCAL-BRS). Pages 196 in *Twentieth Biennial Conference on the Biology of Marine Mammals*, Dunedin, New Zealand.
- Southall, B., and coauthors. 2012. Biological and behavioral response studies of marine mammals in Southern California, 2011 (SOCAL-11) final project report.
- Southall, B. L., and coauthors. 2023. Behavioural responses of fin whales to military mid-frequency active sonar. *Royal Society Open Science* 10(12):231775.
- Southall, B. L., and coauthors. 2019a. Behavioral responses of individual blue whales (*Balaenoptera musculus*) to mid-frequency military sonar. *Journal of Experimental Biology* 222(5):jeb190637.
- Southall, B. L., and coauthors. 2019b. Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects. *Aquatic Mammals* 45(2):125-232.
- Southall, B. L., and coauthors. 2021. Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise. *Aquatic Mammals* 47(5):421-464.
- Southall, B. L., D. P. Nowacek, P. J. O. Miller, and P. L. Tyack. 2016. Experimental field studies to measure behavioral responses of cetaceans to sonar. *Endangered Species Research* 31:293-315.
- Southall, B. L., and coauthors. 2009. Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds. Paper presented at the 18th Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada. .
- Southall, R. B., S. W. Martin, D. L. Webster, and B. L. 2014. Assessment of modeled received sound pressure levels and movements of satellite-tagged odontocetes exposed to mid-frequency active sonar at the Pacific Missile Range Facility: February 2011 through February 2013. U. S. Pacific Fleet.

- Sparrow, V. W. 2002. Review and status of sonic boom penetration into the ocean. *Journal of the Acoustical Society of America* 111(1):537-543.
- Spence, B. C., and R. M. Hughes. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Corporation.
- Spotila, J. R. 2004. Sea turtles: A complete guide to their biology, behavior, and conservation. John Hopkins University Press, Baltimore. 227p.
- Spotila, J. R., and coauthors. 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? *Chelonian Conservation and Biology* 2(2):209-222.
- Sremba, A. L., B. Hancock-Hanser, T. A. Branch, R. L. LeDuc, and C. S. Baker. 2012. Circumpolar diversity and geographic differentiation of mtDNA in the critically endangered Antarctic blue whale (*Balaenoptera musculus intermedia*). *PLoS One* 7(3):e32579.
- St Aubin, D. J., and L. A. Dierauf. 2001. Stress and marine mammals. Pages 253-269 in L. A. D. F. M. D. Gullands, editor. *CRC Handbook of Marine Mammal Medicine*, Second edition. CRC Press, Boca Raton, Florida.
- Stabile, J., J. R. Waldman, F. Parauka, and I. Wirgin. 1996. Stock structure and homing fidelity in Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi*) based on restriction fragment length polymorphism and sequence analyses of mitochondrial DNA. *Genetics* 144(2):767-775.
- Stafford, K. M., C. G. Fox, and D. S. Clark. 1998. Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean (*Balaenoptera musculus*). *Journal of the Acoustical Society of America* 104(6):3616-3625.
- Stafford, K. M., and S. E. Moore. 2005. Atypical calling by a blue whale in the Gulf of Alaska. *Journal of the Acoustical Society of America* 117(5):2724-2727.
- Stanistreet, J. E., and coauthors. 2022. Changes in the acoustic activity of beaked whales and sperm whales recorded during a naval training exercise off eastern Canada. *Scientific Reports* 12(1):1973.
- Staudt, A., and coauthors. 2013. The added complications of climate change: understanding and managing biodiversity and ecosystems. *Frontiers in Ecology and the Environment* 11(9):494-501.
- Stevens, J., and J. Lyle. 1989. Biology of three hammerhead sharks (*Eusphyra blochii*, *Sphyrna mokarran* and *S. lewini*) from northern Australia. *Marine and Freshwater Research* 40(2):129-146.
- Stewart, J. D., and coauthors. 2016. Spatial ecology and conservation of *Manta birostris* in the Indo-Pacific. *Biological Conservation* 200:178-183.
- Stewart, J. D., and coauthors. 2018a. Research priorities to support effective manta and devil ray conservation. *Frontiers in Marine Science* 5:314.
- Stewart, J. D., M. Nuttall, E. L. Hickerson, and M. A. Johnston. 2018b. Important juvenile manta ray habitat at Flower Garden Banks National Marine Sanctuary in the northwestern Gulf of Mexico. *Marine Biology* 165(7):111.
- Steyn. 2010. Exxon Valdez Oil Spill.
- Stoner, A., and R. Appeldoorn. 2021. Synthesis of Research on the Reproductive Biology of Queen Conch (*Aliger gigas*): Toward the Goals of Sustainable Fisheries and Species Conservation. *Reviews in Fisheries Science & Aquaculture* 30:1-45.

- Storelli, M. M., G. Barone, and G. O. Marcotrigiano. 2007. Polychlorinated biphenyls and other chlorinated organic contaminants in the tissues of Mediterranean loggerhead turtle *Caretta caretta*. *Science of the Total Environment* 373(2-3):456-463.
- Storelli, M. M., G. Barone, A. Storelli, and G. O. Marcotrigiano. 2008. Total and subcellular distribution of trace elements (Cd, Cu and Zn) in the liver and kidney of green turtles (*Chelonia mydas*) from the Mediterranean Sea. *Chemosphere* 70(5):908-913.
- Sulak, K., and J. Clugston. 1999. Recent advances in life history of Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*, in the Suwannee River, Florida, USA: a synopsis. *Journal of Applied Ichthyology* 15(4-5):116-128.
- Sulak, K., and coauthors. 2009. Defining winter trophic habitat of juvenile Gulf Sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. *Journal of Applied Ichthyology* 25(5):505-515.
- Sulak, K. J., and J. P. Clugston. 1998. Early life history stages of Gulf sturgeon in the Suwannee River, Florida. *Transactions of the American Fisheries Society* 127(5):758-771.
- Surrey-Marsden, C., and coauthors. 2017. North Atlantic Right Whale Calving Area Surveys: 2015/2016 Results. Southeast Regional Office, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, St. Petersburg, Florida.
- Swope, B., and J. McDonald. 2013. Copper-Based Torpedo Guidance Wire: Applications and Environmental Considerations. San Diego, CA.
- Szesciorka, A. R., and coauthors. 2019. A case study of a near vessel strike of a blue whale: perceptual cues and fine-scale aspects of behavioral avoidance. *Frontiers in Marine Science* 6:761.
- Szmant, A. M. 1986. Reproductive ecology of Caribbean reef corals. *Coral Reefs* 5(1):43-53.
- Szmant, A. M., and M. W. Miller. 2005. Settlement preferences and post-settlement mortality of laboratory cultured and settled larvae of the Caribbean hermatypic corals *Montastrea faveolata* and *Acropora palmata* in the Florida Keys, U.S.A. Pages 43-49 in *Tenth International Coral Reef Symposium*.
- Szmant, A. M., E. Weil, M. W. Miller, and D. E. Colón. 1997. Hybridization within the species complex of the scleractinian coral *Montastraea annularis*. *Marine Biology* 129(4):561-572.
- Taguchi, M., and coauthors. 2021. New Insights Into the Genetic Structure of Sei Whales (*Balaenoptera Borealis*) at the Inter-Oceanic Scale. *Cetacean Population Studies* 3:152-163.
- Tambourgi, M., and coauthors. 2013. Reproductive aspects of the oceanic whitetip shark, *Carcharhinus longimanus* (Elasmobranchii: Carcharhinidae), in the equatorial and southwestern Atlantic Ocean. *Brazilian Journal of Oceanography* 61:161-168.
- Tavolga, W. N., and J. Wodinsky. 1963. Auditory capacities in fishes: Pure tone thresholds in nine species of marine teleosts. *Bulletin of the American Museum of Natural History* 126(2):179-239.
- Taylor, B. L., S. J. Chivers, J. Larese, and W. F. Perrin. 2007. Generation length and percent mature estimates for IUCN assessments of cetaceans. IUCN.
- Tennessen, J., and S. Parks. 2016. Acoustic propagation modeling indicates vocal compensation in noise improves communication range for North Atlantic right whales. *Endangered Species Research*, 30, 225-237.

- Terdalkar, S., A. S. Kulkarni, S. N. Kumbhar, and J. Matheickal. 2005. Bio-economic risks of ballast water carried in ships, with special reference to harmful algal blooms. *Nature, Environment and Pollution Technology* 4(1):43-47.
- TEWG. 2000. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Turtle Expert Working Group, NOAA Technical Memorandum NMFS-SEFSC-444.
- Thompson, P. O., L. T. Findley, O. Vidal, and W. C. Cummings. 1996. Underwater sounds of blue whales, *Balaenoptera musculus*, in the Gulf of California, Mexico. *Marine Mammal Science* 12(2):288-293.
- Thompson, P. O., L. T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. *Journal of the Acoustical Society of America* 92(6):3051-3057.
- Thompson, P. R. 2003. Shock testing of naval vessels using seismic airgun arrays. Google Patents.
- Thomson, D. H., and W. J. Richardson. 1995. Marine mammal sounds. Pages 159-204 in W. J. Richardson, C. R. J. Greene, C. I. Malme, and D. H. Thomson, editors. *Marine Mammals and Noise*. Academic Press, San Diego.
- Thorson, T. B. 1976. Observations on the reproduction of the sawfish, *Pristis perotteti*, in lake Nicaragua, with recommendations for its conservation.
- Tillman, M. F. 1977. Estimates of population size for the North Pacific sei whale. (*Balaenoptera borealis*). Report of the International Whaling Commission Special Issue 1:98-106.- Sc/27/Doc 25).
- Timmers, M. A., C. E. Bird, D. J. Skillings, P. E. Smouse, and R. J. Toonen. 2012. There's No Place Like Home: Crown-of-Thorns Outbreaks in the Central Pacific Are Regionally Derived and Independent Events. *PLoS One* 7(2).
- Tisthammer, K. H., E. Timmins-Schiffman, F. O. Seneca, B. L. Nunn, and R. H. Richmond. 2021. Physiological and molecular responses of lobe coral indicate nearshore adaptations to anthropogenic stressors. *Scientific Reports* 11(1):3423.
- Tolotti, M. T., P. Bach, F. Hazin, P. Travassos, and L. Dagorn. 2015. Vulnerability of the Oceanic Whitetip Shark to Pelagic Longline Fisheries. *PLoS One* PLoS ONE 10(10).
- Tomas, J., and J. A. Raga. 2008. Occurrence of Kemp's ridley sea turtle (*Lepidochelys kempii*) in the Mediterranean. *Marine Biodiversity Records* 1(01).
- Tomascik, T. 1990. Growth rates of two morphotypes of *Montastrea annularis* along a eutrophication gradient, Barbados, WI. *Marine Pollution Bulletin* 21(8):376-381.
- Tomascik, T., and F. Sander. 1987. Effects of eutrophication on reef-building corals. II. Structure of scleractinian coral communities on fringing reefs, Barbados, West Indies. *Marine Biology* 94(1):53-75.
- Tricas, T., and J. New. 1997. Sensitivity and response dynamics of elasmobranch electrosensory primary afferent neurons to near threshold fields. *Journal of Comparative Physiology A* 182:89-101.
- Truelove, N. K., and coauthors. 2017. Isolation by oceanic distance and spatial genetic structure in an overharvested international fishery. *Diversity and Distributions* 23(11):1292-1300.
- Trygonis, V., E. Gerstein, J. Moir, and S. McCulloch. 2013. Vocalization characteristics of North Atlantic right whale surface active groups in the calving habitat, southeastern United States. *Journal of the Acoustical Society of America* 134(6):4518.

- Tunnell, J. W. J. 1988. Regional comparison of southwestern Gulf of Mexico to Caribbean Sea coral reefs. Pages 303-308 in *Proceedings Of The Sixth International Coral Reef Symposium*, Townsville, Australia.
- Twiner, M. J., and coauthors. 2011. Concurrent exposure of bottlenose dolphins (*Tursiops truncatus*) to multiple algal toxins in Sarasota Bay, Florida, USA. *PLoS One* 6(3):e17394.
- Twiner, M. J., and coauthors. 2012. Comparative analysis of three brevetoxin-associated bottlenose dolphin (*Tursiops truncatus*) mortality events in the Florida panhandle region (USA). *PLoS One* 7(8):e42974.
- Tyack, P. L. 1999. Communication and cognition. Pages 287-323 in J. E. Reynolds III, and S. A. Rommel, editors. *Biology of Marine Mammals*. Smithsonian Institution Press, Washington.
- Tyack, P. L., and coauthors. 2011. Beaked whales respond to simulated and actual Navy sonar. *PLoS One* 6(3):e17009.
- Tyson, R. B., D. P. Nowacek, and P. J. O. Miller. 2007. Nonlinear phenomena in the vocalizations of North Atlantic right whales (*Eubalaena glacialis*) and killer whales (*Orcinus orca*). *Journal of the Acoustical Society of America* 122(3):1365-1373.
- U.S. Department of the Air Force. 2016. United States Air Force F-35A Operational Beddown - Pacific Final Environmental Impact Statement.
- U.S. Department of the Army. 1999. Finding of No Significant Impact (FONSI) for the Life Cycle Environmental Assessment (LCEA) for the HELLFIRE Modular Missile System.
- U.S. Department of the Navy. 2001. *Airborne Mine Neutralization System (AMNS) Inert Target Tests: Environmental Assessment and Overseas Environmental Assessment*. Coastal Systems Station, Panama City, FL.
- U.S. Department of the Navy. 2013. Petition for Regulations Pursuant to Section 101(a)(5) of the Marine Mammal Protection Act covering taking of Marine Mammals Incidental to Target and Missile Launch Activities for the Period 2014–2019 at San Nicolas Island, California (50 CFR Part 216, Subpart I). N. M. F. S. Office of Protected Resources, National Oceanographic and Atmospheric Administration, editor, Point Mugu, CA.
- U.S. Department of the Navy. 2017. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). Space and Naval Warfare System Command, Pacific.
- U.S. Department of the Navy. 2023. Assessment of Military Expended Material Impacts on Protected Corals and Designated Coral Critical Habitat in the Key West Range Complex. Naval Undersea Warfare Center Division, Newport, RI.
- Urick, R. J. 1983. *Principles of Underwater Sound*, 3rd edition. Peninsula Publishing, Los Altos, California.
- USAF, U. S. A. F. 2000. *Supersonic Aircraft Noise at and Beneath the Ocean Surface: Estimation of Risk for Effects on Marine Mammals*. .
- USCOP. 2004. *An ocean blueprint for the 21st century. Final report*. U.S. Commission on Ocean Policy, Washington, D. C.
- USDOJ. 2012. *Natural Resource Damage Assessment: April 2012 status update for the Deepwater Horizon oil spill*. U.S. Department of the Interior.
- USFWS, and P. B. Gaston. 1988. *Atlantic salmon culture for restoration*.
- USFWS, and GSMFC. 1995. *Gulf sturgeon recovery plan*. U.S. Fish and Wildlife Service, Gulf States Marine Fisheries Commission, Atlanta, Georgia.

- USFWS, and NMFS. 2009. Gulf sturgeon (*Acipenser oxyrinchus desotoi*) 5-year review: Summary and evaluation. U.S. Fish and Wildlife Service and National Marine Fisheries Service.
- USFWS, and NMFS. 2019. Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon (*Salmo salar*): Final Plan for the 2009 ESA Listing. US Fish and Wildlife Service, National Marine Fisheries Service.
- USFWS and NMFS. 2022. Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, South Atlantic-Gulf and Mississippi Basin Regions, Panama City Fish and Wildlife Conservation Office, Panama City, Florida and National Marine Fisheries Service
- Southeast Region, Protected Resources Division, St. Petersburg, Florida
- USFWS, N. 2013. Hawksbill sea turtle (*Eremochelys imbricata*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service.
- USFWS, N. 2020. Atlantic salmon (*Salmo salar*) 5-Year Review: Summary and Evaluation. G. A. R. F. Office, editor. NMFS, Gloucester, MA.
- USFWS, N. a. 1998. Recovery plan for the U.S. Pacific populations of the leatherback turtle (*Dermochelys coriacea*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Washington, D.C.
- USGCRP. 2023. Fifth National Climate Assessment. U.S. Global Change Research Program, Washington, DC, USA.
- USN. 2009. Gulf of Mexico range complex final environmental impact statement/overseas environmental impact statement (EIS/OEIS) volume 1 (version 3). United States Navy, Norfolk, Virginia.
- Van de Merwe, J. P. V., and coauthors. 2009. Chemical contamination of green turtle (*Chelonia mydas*) eggs in peninsular Malaysia: Implications for conservation and public health. *Environmental Health Perspectives* 117(9):1397-1401.
- van de Water, J. A., J. B. Lamb, M. J. van Oppen, B. L. Willis, and D. G. Bourne. 2015. Comparative immune responses of corals to stressors associated with offshore reef-based tourist platforms. *Conservation Physiology* 3(1):cov032.
- van der Hoop, J., P. Corkeron, and M. Moore. 2017a. Entanglement is a costly life-history stage in large whales. *Ecol Evol* 7(1):92-106.
- Van der Hoop, J. M., and coauthors. 2019. Foraging rates of ram-filtering North Atlantic right whales. *Functional Ecology* 33(7):1290-1306.
- van der Hoop, J. M., D. P. Nowacek, M. J. Moore, and M. Triantafyllou. 2017b. Swimming kinematics and efficiency of entangled North Atlantic right whales. *Endangered Species Research* 32:1-17.
- Van Dolah, F. M. 2005. Effects of harmful algal blooms. *Marine mammal research: Conservation beyond crisis*:85-99.
- Van Eenennaam, J., and coauthors. 1996. Reproductive conditions of the Atlantic sturgeon (*Acipenser oxyrinchus*) in the Hudson River. *Estuaries and Coasts* 19(4):769-777.
- Van Scheppingen, W. B., A. J. I. M. Verhoeven, P. Mulder, M. J. Addink, and C. Smeenk. 1996. Polychlorinated-biphenyls, dibenzo-p-dioxins, and dibenzofurans in harbor porpoises *Phocoena phocoena* stranded on the Dutch coast between 1990 and 1993. *Archives of Environmental Contamination and Toxicology* 30:492-502.
- Van Waerebeek, K., and R. Leaper. 2008. Second report of the IWC vessel strike data standardisation working group. IWC Scientific Committee document SC/60/BC5 620.

- Vandeperre, F., and coauthors. 2019. Relative abundance of oceanic juvenile loggerhead sea turtles in relation to nest production at source rookeries: implications for recruitment dynamics. *Scientific Reports* 9(1):13019.
- Vanderlaan, A. S., and C. T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. *Marine Mammal Science* 23(1):144-156.
- Vanderlaan, A. S. M., A. E. Hay, and C. T. Taggart. 2003. Characterization of North Atlantic right whale (*Eubalaena glacialis*) sounds in the Bay of Fundy. *IEEE Journal of Oceanic Engineering* 28(2):164-173.
- Vanderlaan, A. S. M., C. T. Taggart, A. R. Serdynska, R. D. Kenney, and M. W. Brown. 2008. Reducing the risk of lethal encounters: Vessels and right whales in the Bay of Fundy and on the Scotian Shelf. *Endangered Species Research* 4(3):283-283.
- Vargo, S., P. Lutz, D. Odell, E. V. Vleet, and G. Bossart. 1986. Study of the effects of oil on marine turtles. Minerals Management Service, Vienna, Virginia.
- Vaz, A., and coauthors. 2022. Exploitation Drives Changes in the Population Connectivity of Queen Conch (*Aliger gigas*). *Frontiers in Marine Science* 9:841027.
- Venables, S. 2013. Short term behavioural responses of manta rays, *Manta alfredi*, to tourism interactions in Coral Bay, Western Australia. Murdoch University.
- Vereide, E. H., and coauthors. 2023. Effects of airgun discharges used in seismic surveys on development and mortality in nauplii of the copepod *Acartia tonsa*. *Environmental Pollution* 327:121469.
- Viehman, T. S., and coauthors. 2020. Coral assessment and restoration in the U.S. Caribbean after 2017 hurricanes. Restoration Demonstration Project: Experimental input into designing coral restoration for coastal protection.
- Vilas, D., and coauthors. 2023. Evaluating red tide effects on the West Florida Shelf using a spatiotemporal ecosystem modeling framework. *Scientific Reports* 13(1):2541.
- Vilela, R., U. Pena, R. Esteban, and R. Koemans. 2016. Bayesian spatial modeling of cetacean sightings during a seismic acquisition survey. *Marine Pollution Bulletin* 109(1):512–520.
- Villegas-Amtmann, S., L. K. Schwarz, J. L. Sumich, and D. P. Costa. 2015. A bioenergetics model to evaluate demographic consequences of disturbance in marine mammals applied to gray whales. *Ecosphere* 6(10).
- Villinski, J. T. 2003. Depth-independent reproductive characteristics for the Caribbean reef-building coral *Montastraea faveolata*. *Marine Biology* 142(6):1043-1053.
- Vine, J. R., S. C. Holbrook, W. C. Post, and B. K. Peoples. 2019. Identifying environmental cues for Atlantic sturgeon and shortnose sturgeon spawning migrations in the Savannah River. *Transactions of the American Fisheries Society* 148(3):671-681.
- Vinson, M. R., and M. A. Baker. 2008. Poor growth of rainbow trout fed New Zealand mud snails *Potamopyrgus antipodarum*. *North American Journal of Fisheries Management* 28(3):701-709.
- von Benda-Beckmann, A. M., and coauthors. 2021. Modeling potential masking of echolocating sperm whales exposed to continuous 1–2 kHz naval sonar. *The Journal of Acoustical Society of America* 149:2908–2925.
- Waddell, J. E. 2005. The state of coral reef ecosystems of the United States and Pacific freely associated states: 2005. NOAA, NOS, NCCOS, Center for Coastal Monitoring and Assessment's Biogeography Team, NOAA Technical Memorandum NOS NCCOS 11., Silver Spring, Maryland.

- Wade, P. R., and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Report of the International Whaling Commission 43(477-493).
- Wagner, D. E., P. Kramer, and R. van Woesik. 2010. Species composition, habitat, and water quality influence coral bleaching in southern Florida. *Marine Ecology Progress Series* 408:65-78.
- Waldman, J., and coauthors. 2019. Contemporary and historical effective population sizes of Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus*. *Conservation Genetics* 20:167-184.
- Waldman, J. R., C. Grunwald, J. Stabile, and I. Wirgin. 2002. Impacts of life history and biogeography on the genetic stock structure of Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus*, Gulf sturgeon *A. oxyrinchus desotoi*, and shortnose sturgeon *A. brevirostrum*. *Journal of Applied Ichthyology* 18(4-6):509-518.
- Waldman, J. R., K. Nolan, J. Hart, and I. I. Wirgin. 1996. Genetic differentiation of three key anadromous fish populations of the Hudson River. *Estuaries* 19(4):759-768.
- Waldman, J. R., and I. I. Wirgin. 1998. Status and Restoration Options for Atlantic Sturgeon in North America. *Conservation Biology* 12(3):631-638.
- Walker, B. 2018. Southeast Florida reef-wide Post-Irma coral disease surveys. Florida DEP, Miami, FL.
- Walker, M. M., J. L. Kirschvink, G. Ahmed, and A. E. Dizon. 1992. Evidence that fin whales respond to the geomagnetic field during migration. *Journal of Experimental Biology* 171(1):67-78.
- Wallace, B. P., and coauthors. 2007. Maternal investment in reproduction and its consequences in leatherback turtles. *Oecologia* 152(1):37-47.
- Wallace, C. C. 1985. Reproduction, recruitment and fragmentation in nine sympatric species of the coral genus *Acropora*. *Marine Biology* 88(3):217-233.
- Wambiji, N., P. Gwada, E. Fondo, S. Mwangi, and M. K. Osore. 2007. Preliminary results from a baseline survey of the port of Mombasa: with focus on molluscs. 5th Western Indian Ocean Marine Science Association Scientific Symposium; Science, Policy and Management pressures and responses in the Western Indian Ocean region, Durban, South Africa.
- Wang, Z., T. Boyer, J. Reagan, and P. Hogan. 2023. Upper-Oceanic Warming in the Gulf of Mexico between 1950 and 2020. *Journal of Climate* 36(8):2721-2734.
- Ward, S. L. C., and J. W. 1943. The effects of rapid compression waves on animals submerged in water. *Surgery, Gynecology and Obstetrics* 77:403-412.
- Waring, C. P., and A. Moore. 2004. The effect of atrazine on Atlantic salmon (*Salmo salar*) smolts in fresh water and after sea water transfer. *Aquatic Toxicology* 66(1):93-104.
- Wartzok, D., A. N. Popper, J. Gordon, and J. Merrill. 2003. Factors affecting the responses of marine mammals to acoustic disturbance. *Marine Technology Society Journal* 37(4):15-Jun.
- Watkins, W. A. 1977. Acoustic behavior of sperm whales. *Oceanus* 20:50-58.
- Watkins, W. A. 1981. Activities and underwater sounds of fin whales (*Balaenoptera physalus*). *Scientific Reports of the Whales Research Institute Tokyo* 33:83-117 & 118.
- Watkins, W. A. 1985. Changes observed in the reaction of whales to human activities. National Marine Fisheries Service.
- Watkins, W. A. 1986. Whale reactions to human activities in Cape Cod waters. *Marine Mammal Science* 2(4):251-262.

- Watkins, W. A., M. A. Daher, K. M. Fristrup, T. J. Howald, and G. N. Disciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. *Marine Mammal Science* 9(1):55-67.
- Watkins, W. A., K. E. Moore, and P. L. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. *Cetology* 49:1-15.
- Watkins, W. A., and W. E. Schevill. 1975. Sperm whales (*Physeter catodon*) react to pingers. *Deep Sea Research and Oceanographic Abstracts* 22(3):123-129 +1pl.
- Watkins, W. A., and W. E. Schevill. 1977. Spatial distribution of *Physeter catodon* (sperm whales) underwater. *Deep Sea Research* 24(7):693-699.
- Watkins, W. A., P. Tyack, K. E. Moore, and J. E. Bird. 1987. The 20-Hz signals of finback whales (*Balaenoptera physalus*). *Journal of the Acoustical Society of America* 82(6):1901-1912.
- Watters, D., M. Yoklavich, M. Love, and D. Schroeder. 2010. Assessing marine debris in deep seafloor habitats off California. *Marine Pollution Bulletin* 60:131-138.
- Watterson, J., C. Hager, and J. Kahn. 2017. Depth ranges utilized by Atlantic sturgeon tagged in the Pamunkey River, Virginia based on acoustic telemetry data [Unpublished data]. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic.
- Watwood, S. L., P. J. O. Miller, M. Johnson, P. T. Madsen, and P. L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). *Journal of Animal Ecology* 75:814-825.
- Weil, E., and N. Knowton. 1994. A multi-character analysis of the Caribbean coral *Montastraea annularis* (Ellis and Solander, 1786) and its two sibling species, *M. faveolata* (Ellis and Solander, 1786) and *M. franksi* (Gregory, 1895). *Bulletin of Marine Science* 55(1):151-175.
- Weilgart, L. 2013. A review of the impacts of seismic airgun surveys on marine life. Pages 1-10 in CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity. London, United Kingdom.
- Weilgart, L., and H. Whitehead. 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galápagos Islands. *Canadian Journal of Zoology* 71(4):744-752.
- Weilgart, L. S., and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. *Behavioral Ecology and Sociobiology* 40(5):277-285.
- Weir, C. R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. *Aquatic Mammals* 34(1):71-83.
- Weir, C. R., A. Frantzis, P. Alexiadou, and J. C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). *Journal of the Marine Biological Association of the U.K.* 87(1):39-46.
- Weirathmueller, M. J., W. S. D. Wilcock, and D. C. Soule. 2013. Source levels of fin whale 20 Hz pulses measured in the Northeast Pacific Ocean. *Journal of the Acoustical Society of America* 133(2):741-749.
- Wells, R. S., and coauthors. 2008. Consequences of injuries on survival and reproduction of common bottlenose dolphins (*Tursiops truncatus*) along the west coast of Florida. *Marine Mammal Science* 24(4):774-794.

- Wensveen, P., and coauthors. 2017. Lack of behavioural responses of humpback whales (*Megaptera novaeangliae*) indicate limited effectiveness of sonar mitigation. *Journal of Experimental Biology* 220:4150-4161.
- Wensveen, P. J., and coauthors. 2019. Northern bottlenose whales in a pristine environment respond strongly to close and distant navy sonar signals. *Proceedings of the Royal Society of London B: Biological Science* 286(1899):20182592.
- Wenzel, F., D. K. Mattila, and P. J. Clapham. 1988. *Balaenoptera musculus* in the Gulf of Maine. *Marine Mammal Science* 4(2):172-175.
- Westell, A., and coauthors. 2024. Acoustic presence and demographics of sperm whales (*Physeter macrocephalus*) off southern New England and near a US offshore wind energy area. *ICES Journal of Marine Science*:fsae012.
- Wheaton, J. L., and W. C. Jaap. 1988. Corals and Other Prominent Benthic Cnidaria of Looe Key National Marine Sanctuary, Florida. Florida Department of Natural Resources, Bureau of Marine Research.
- White, S. L., and coauthors. 2021a. Stock Composition of the Historical New York Bight Atlantic Sturgeon Fishery Revealed through Microsatellite Analysis of Archived Spines. *Marine and Coastal Fisheries* 13(6):720-727.
- White, S. L., and coauthors. 2021b. Establishment of a microsatellite genetic baseline for North American Atlantic sturgeon (*Acipenser o. oxyrinchus*) and range-wide analysis of population genetics. *Conservation Genetics*.
- White, W., C. Bartron, and I. Potter. 2008. Catch composition and reproductive biology of *Sphyrna lewini* (Griffith & Smith)(Carcharhiniformes, Sphyrnidae) in Indonesian waters. *Journal of Fish Biology* 72(7):1675-1689.
- Whitehead, H. 2003. Society and culture in the deep and open ocean: The sperm whale and other cetaceans. Pages 616 in F. B. M. d. Waal, and P. L. Tyack, editors. *Animal Social Complexity: Intelligence, Culture, and Individualized Societies*. Harvard University Press.
- Whitehead, H. 2009. Sperm whale: *Physeter macrocephalus*. Pages 1091-1097 in W. F. Perrin, B. Würsig, and J. G. M. Thewissen, editors. *Encyclopedia of Marine Mammals*, Second edition. Academic Press, San Diego, California.
- Whitehead, H., and M. Shin. 2022. Current global population size, post-whaling trend and historical trajectory of sperm whales. *Scientific Reports* 12(1):19468.
- Whitehead, H., and L. Weilgart. 1991. Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. *Behaviour* 118(3/4):275-295.
- Whitt, A. D., K. Dudzinski, and J. R. Laliberte. 2013. North Atlantic right whale distribution and seasonal occurrence in nearshore waters off New Jersey, USA, and implications for management. *Endangered Species Research* 20(1):59-69.
- Wiggins, S. M., E. M. Oleson, M. A. McDonald, and J. A. Hildebrand. 2005. Blue whale (*Balaenoptera musculus*) diel call patterns offshore of southern California. *Aquatic Mammals* 31(2):161-168.
- Wilcove, D. S., and L. Y. Chen. 1998. Management costs for endangered species. *Conservation Biology* 12(6):1405-1407.
- Wildermann, N. E., C. R. Sasso, L. W. Stokes, D. Snodgrass, and M. M. Fuentes. 2019. Habitat use and behavior of multiple species of marine turtles at a foraging area in the Northeastern Gulf of Mexico. *Frontiers in Marine Science* 6:155.

- Wiles, G. 2017. Periodic status review for the blue, fin, sei, North Pacific right, and sperm whales in Washington. Washington Department of Fish and Wildlife, Olympia, Washington 46.
- Wiley, T. R., and C. A. Simpfendorfer. 2010. Using public encounter data to direct recovery efforts for the endangered smalltooth sawfish *Pristis pectinata*. *Endangered Species Research* 12:179-191.
- Wilkinson, C., editor. 2008. Status of coral reefs of the world: 2008. Global Coral Reef Monitoring Network, Reef Rainforest Research Centre, Townsville.
- Willford, W., and coauthors. 1981. Chlorinated hydrocarbons as a factor in the reproduction and survival of lake trout (*Salvelinus namaycush*). U.S. Dept. of the Interior, U.S. Fish and Wildlife Service.
- Williams, D. E., and M. W. Miller. 2010. Stabilization of fragments to enhance asexual recruitment in *Acropora palmata*, a threatened Caribbean coral. *Restoration Ecology* 18(S2):446-451.
- Williams, D. E., M. W. Miller, and K. L. Kramer. 2008. Recruitment failure in Florida Keys *Acropora palmata*, a threatened Caribbean coral. *Coral Reefs* 27:697-705.
- Williams, D. E., K. Nedimyer, and M. W. Miller. 2020. Genotypic inventory of *Acropora palmata* (elkhorn coral) populations in south Florida, Protected Resources and Biodiversity Division Report: NOAA/SEFSC/PRBD-2020-01, NOAA NMFS Southeast Fisheries Science Center.
- Williams, R., E. Ashe, and P. D. O'hara. 2011. Marine mammals and debris in coastal waters of British Columbia, Canada. *Marine Pollution Bulletin* 62(6):1303-1316.
- Williams, R., D. E. Bain, J. K. B. Ford, and A. W. Trites. 2002. Behavioural responses of male killer whales to a leapfrogging vessel. *Journal of Cetacean Research and Management* 4(3):305-310.
- Wippelhauser, G. S., and coauthors. 2017. Movements of Atlantic Sturgeon of the Gulf of Maine inside and outside of the geographically defined distinct population segment. *Marine and Coastal Fisheries* 9(1):93-107.
- Wirgin, I., N. K. Roy, L. Maceda, and M. T. Mattson. 2018. DPS and population origin of subadult Atlantic Sturgeon in the Hudson River. *Fisheries Research* 207:165-170.
- Wirgin, I., and coauthors. 2000. Genetic structure of Atlantic sturgeon populations based on mitochondrial DNA control region sequences. *Transactions of the American Fisheries Society* 129(2):476-486.
- Wise, J. P., and coauthors. 2008. Hexavalent chromium is cytotoxic and genotoxic to the North Atlantic right whale (*Eubalaena glacialis*) lung and testes fibroblasts. *Mutation Research* 650:30-38.
- Witherington, B., S. Hirama, and R. Hardy. 2012a. Young sea turtles of the pelagic *Sargassum*-dominated drift community: habitat use, population density, and threats. *Marine Ecology Progress Series* 463:1-22.
- Witherington, B., and coauthors. 2012b. Efforts to rescue oiled turtles at sea during the BP *Deepwater Horizon* blowout event, April-September 2010. Pages 21 in T. T. Jones, and B. P. Wallace, editors. Thirty-First Annual Symposium on Sea Turtle Biology and Conservation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, San Diego, California.
- Wolfe, S. H., J. A. Reidenauer, and D. B. Means. 1988. An ecological characterization of the Florida Panhandle. U.S. Fish and Wildlife Service and MMS, New Orleans, Louisiana.

- Woodley, T. H., M. W. Brown, S. D. Kraus, and D. E. Gaskin. 1991. Organochlorine levels in North Atlantic right whales (*Eubalaena glacialis*) blubber. *Archives of Environmental Contamination and Toxicology* 21:141-145.
- Wooley, C. M., and E. J. Crateau. 1985. Movement, microhabitat, exploitation, and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. *North American Journal of Fisheries Management* 5(4):590-605.
- Work, P. A., A. L. Sapp, D. W. Scott, and M. G. Dodd. 2010. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. *Journal of Experimental Marine Biology and Ecology* 393(1-2):168-175.
- Worm, B., and coauthors. 2024. Global shark fishing mortality still rising despite widespread regulatory change. *Science* 383(6679):225-230.
- Wuebbles, D. J., and coauthors. 2017. Our globally changing climate. Pages 35-72 in D. J. Wuebbles, and coeditors, editors. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. U.S. Global Change Research Program, Washington, DC, USA.
- Wursig, B., S. K. Lynn, T. A. Jeffereson, and K. D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals* 24.1:41-50.
- Wyneken, J., and M. Salmon. 1992. Frenzy and postfrenzy swimming activity in loggerhead, green and leatherback hatchling sea turtles. *Copeia* 1992(2):478-484.
- Wysocki, L. E., J. P. Dittami, and F. Ladich. 2006. Ship noise and cortisol secretion in European freshwater fishes. *Biological Conservation* 128(4):501-508.
- Yagla, J., and R. Stiegler. 2003. Gun blast noise transmission across the air-sea interface. Pages 9-Jan in *Euronoise*, Naples.
- Yakich, D. M., A. K. Wooley, L. B. Heath, and G. R. Poulakis. 2024. Effects of marine debris and human interactions on the smalltooth sawfish (*Pristis pectinata*). *Marine Pollution Bulletin* 206:116606.
- Yan, B. M. C. P. S. L. H. Y. 2003. The hearing sensitivity of the little skate, *Raja erinacea*: A comparison of two methods. *Environmental Biology of Fishes* 68(4):371-379.
- Yang, W.-C., and coauthors. 2021. Anthropogenic sound exposure-induced stress in captive dolphins and implications for cetacean health. *Frontiers in Marine Science* 8.
- Yazvenko, S. B., and coauthors. 2007. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. *Environmental Monitoring and Assessment* 134(1-3):93-106.
- Yelverton, J. T., D. R. Richmond, E. R. Fletcher, and R. K. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Defense Nuclear Agency.
- Yender, R., J. Michel, and C. Lord. 2002. Managing seafood safety after an oil spill. National Oceanic and Atmospheric Administration, National Ocean Service, Office of Response and Restoration, Seattle, Washington.
- Young, C. N., and coauthors. 2017. Status review report: oceanic whitetip shark (*Carcharhinus longimanus*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.
- Young, C. N., and J. K. Carlson. 2020. The biology and conservation status of the oceanic whitetip shark (*Carcharhinus longimanus*) and future directions for recovery. *Reviews in Fish Biology and Fisheries* 30(2):293-312.

- Young, G. A. 1991. Concise Methods for Predicting the Effects of Underwater Explosions on Marine Life. Naval Surface Warfare Center, Silver Spring, MD.
- Zimmer, B., W. Precht, E. Hickerson, and J. Sinclair. 2006. Discovery of *Acropora palmata* at the Flower Garden Banks National Marine Sanctuary, northwestern Gulf of Mexico. *Coral Reefs* 25:192.
- Zoidis, A. M., and coauthors. 2021. Distribution and density of six large whale species in the New York Bight from monthly aerial surveys 2017 to 2020. *Continental Shelf Research* 230:104572.
- Zona, J. O., B. R. Kreiser, A. J. Kaeser, A. G. Fox, and M. J. D'Ercole. 2025. Genetic evidence for a fall spawning group of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the Apalachicola River, Florida. *bioRxiv*:2025.01. 29.635482.