NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
SECTION 7 BIOLOGICAL OPINION

Title:	Biological Opinion on (1) United States (U.S.) Navy Mariana Islands Training and Testing Activities; 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 Mariana Islands Training and Testing activities from August 2020 through August 2027
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:	United States Navy and NOAA's National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division
Publisher:	Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Approved:	WIETING.DONNA.S.1365710607 Digitally signed by WIETING.DONNA.S.1365710607 Date: 2020.07.10 15:42:38 -04'00' Donna S. Wieting Director, Office of Protected Resources
Date:	July 10, 2020
Consultation Tracking number:	OPR-2019-00469
Digital Object Identifier (DOI):	https://doi.org/10.25923/6r20-b791

This page left blank intentionally

TABLE OF CONTENTS

Page

1 Introduction 14
1.1 Background 16
1.2 Endangered Species Act (ESA) Consultation History 16

2 The Assessment Framework 21
2.1 Evidence Available for this Consultation 24
2.2 Acoustic Effects Analysis 25
2.2.1 Navy Acoustic Effects Model and Post-Processing Model Outputs 25
2.2.2 Criteria and Thresholds to Predict Impacts to Marine Mammals and Sea Turtles 29
2.2.3 Species Density Estimates 42
2.2.4 Criteria and Thresholds to Predict Impacts to Fish 49

3 Description of the Proposed Action 51
3.1 Mariana Islands Training Activities 52
3.1.1 Anti-Air Warfare 52
3.1.2 Amphibious Warfare 53
3.1.3 Strike Warfare 54
3.1.4 Anti-Surface Warfare 55
3.1.5 Anti-Submarine Warfare 56
3.1.6 Electronic Warfare 57
3.1.7 Mine Warfare 58
3.1.8 Expeditionary Warfare 60
3.1.9 Major Training Exercises and Other Training Activities 60
3.2 Mariana Islands Testing Activities 61
3.2.1 Naval Air Systems Command Testing Activities 62
3.2.2 Naval Sea Systems Command Testing Activities 63
3.2.3 Office of Naval Research Activities 65
3.3 Classification of Navy Sonar and Explosive Sources into Bins 66
3.4 Proposed Training Activity Levels 70
3.5 Proposed Testing Activity Levels 81
3.6 Standard Operating Procedures and Mitigation Measures 84
3.6.1 Standard Operating Procedures 84
3.6.2 Mitigation Measures 87
3.7 Promulgation of Marine Mammal Protection Act Regulations 125

4 Action Area 126
4.1 Mariana Islands Range Complex 126
4.1.1 Special Use Airspace and Air Traffic Controlled Assigned Airspace 126

4.1.2 Sea and Undersea Space ... 128
4.1.3 Land ... 129
4.2 Ocean Operating Areas Outside of the Mariana Islands Range Complex ... 133
4.3 Pierside Locations and Apra Harbor ... 134
4.4 Nearshore Training and Testing Areas ... 134

5 Potential Stressors ... 138
5.1 Acoustic Stressors ... 138
5.1.1 Sonar and other Transducers ... 138
5.1.2 Explosives ... 140
5.1.3 Vessel Noise ... 142
5.1.4 Aircraft Noise ... 143
5.1.5 Weapons Firing, Launch and Impact Noise ... 147
5.2 Energy Stressors ... 149
5.2.1 Electromagnetic Devices ... 149
5.2.2 Lasers ... 150
5.3 Physical Disturbance and Strike Stressors ... 150
5.3.1 Vessel Strike ... 150
5.3.2 Military Expended Materials, In-Water Devices and Seafloor Devices ... 153
5.3.3 Cavitation from Vessels and In-Water Devices ... 153
5.3.4 Anchoring ... 154
5.3.5 Personnel Disturbance ... 154
5.4 Entanglement Stressors ... 154
5.4.1 Wires and Cables ... 154
5.4.2 Decelerators and Parachutes ... 155
5.5 Ingestion Stressors ... 156
5.5.1 Non-Explosive Practice Munitions ... 157
5.5.2 Fragments from High Explosive Munitions ... 157
5.5.3 Target Related Materials ... 157
5.5.4 Chaff ... 157
5.5.5 Flares ... 158
5.6 Secondary Stressors ... 158

6 Species and Designated Critical Habitat that May be Affected ... 159
6.1 Species Not Likely to be Adversely Affected ... 160
6.1.1 Olive Ridley Sea Turtle ... 161
6.1.2 *Acropora retusa* ... 162
6.1.3 *Seriatopora aculeata* ... 163
6.2 Status of the Species Likely to be Adversely Affected by the Proposed Action ... 164
6.2.1 Blue Whale ... 165
6.2.2 Fin Whale ... 170

6.2.3 Humpback Whale – Western North Pacific Distinct Population Segment (DPS) 175
6.2.4 Sei Whale 182
6.2.5 Sperm Whale 187
6.2.6 Green Sea Turtle 191
6.2.7 Hawksbill Sea Turtle 201
6.2.8 Leatherback Sea Turtle 205
6.2.9 Loggerhead Sea Turtle – North Pacific DPS 211
6.2.10 Scalloped Hammerhead Shark – Indo-West Pacific DPS 216
6.2.11 Giant Manta Ray 220
6.2.12 Oceanic Whitetip Shark 222
6.2.13 *Acropora globiceps* 227

7 Environmental Baseline 233
7.1 Climate Change 233
7.1.1 Ocean Acidification and Coral Bleaching 237
7.2 Oceanic Temperature Regimes 238
7.3 Coastal Development and Pollution 239
7.3.1 Light Pollution 241
7.4 Marine Debris 241
7.5 Fisheries 244
7.5.1 Bycatch 245
7.5.2 Directed Fisheries 246
7.6 Whaling 248
7.7 Ongoing U.S. Military Training and Testing Activities in the action area 250
7.8 Other U.S. Military Activities in the Action Area 252
7.8.1 Surveillance Towed Array Sensor System Low Frequency Active Sonar 252
7.8.2 Dredging, Filling, and Explosive Clearing 253
7.9 Vessel Strike 254
7.10 Ocean Noise 257
7.11 Scientific Research and Permits 258
7.12 Strandings 258

8 Effects of the Action on Species and Critical Habitat 262
8.1 Stressors Not Likely to Adversely Affect ESA-Listed Species 266
8.1.1 Cetaceans 266
8.1.2 Sea Turtles 294
8.1.3 Fishes 314
8.1.4 Corals 332
8.2 Stressors Likely to Adversely Affect ESA-Listed Species 337
8.2.1 Cetaceans 338

8.2.2 Sea Turtles ... 423
8.2.3 Fishes – Effects of Explosive Stressors ... 441
8.2.4 Coral – Effects of Explosives and Military Expended Materials ... 449

9 Cumulative Effects ... 462

10 Integration and Synthesis ... 463
10.1 Cetaceans ... 464
10.1.1 Blue Whale ... 465
10.1.2 Fin Whale ... 466
10.1.3 Humpback Whale – Western North Pacific DPS ... 467
10.1.4 Sei Whale ... 472
10.1.5 Sperm Whale ... 473
10.2 Sea Turtles ... 474
10.2.1 Green Sea Turtle ... 477
10.2.2 Hawksbill sea turtle ... 484
10.2.3 Leatherback Sea Turtle ... 486
10.2.4 Loggerhead Sea Turtle – North Pacific DPS ... 487
10.3 Fishes ... 488
10.3.1 Scalloped Hammerhead Shark – Indo-West Pacific DPS ... 489
10.3.2 Giant Manta Ray ... 491
10.3.3 Oceanic Whitetip Shark ... 493
10.4 Coral - *Acropora globiceps* ... 495

11 Conclusion ... 497

12 Incidental Take Statement ... 498
12.1 Amount or Extent of Take ... 499
12.2 Effects of the Take ... 503
12.3 Reasonable and Prudent Measures ... 503
12.4 Terms and Conditions ... 504

13 Conservation Recommendations ... 507

14 Reinitiation of Consultation ... 509

15 References ... 510

LIST OF TABLES

Page

Table 1. Acoustic thresholds identifying the onset of temporary threshold shift (TTS) and permanent threshold shift (PTS) for non-impulsive sound sources by functional hearing group (Navy 2017a). 31

Table 2. Onset of TTS and PTS in marine mammals for explosives, air guns, and impact pile driving. 32

Table 3. Criteria to quantitatively assess marine mammal and sea turtle non-auditory injury due to underwater explosions (second column) and criteria for estimating ranges to potential effect for mitigation purposes (third column). 33

Table 4. Cutoff distances for moderate source level, single platform training and testing events and events with multiple platforms or sonar with high sources levels[1] (Navy 2017a). 37

Table 5. Phase III behavioral thresholds for explosives for marine mammals underwater (Navy 2017a). 37

Table 6. Acoustic thresholds identifying the onset of PTS and TTS for sea turtles exposed to impulsive sounds (Navy 2017a). 39

Table 7. Density estimates for ESA-listed marine mammals in the action area. 43

Table 8. Summary of Navy Density Estimates for Green Sea Turtles in the action area (Navy 2019e). 45

Table 9. Summary of Navy Density Estimates for Hawksbill Sea Turtles in the action area (Navy 2019e). 47

Table 10. Anti-Air warfare training exercises. 53

Table 11. Typical amphibious warfare training exercises. 54

Table 12. Strike warfare training exercises. 55

Table 13. Anti-surface warfare training exercises. 55

Table 14. Anti-submarine warfare training exercises. 57

Table 15. Electronic warfare training exercises. 58

Table 16. Mine warfare exercises. 59

Table 17. Expeditionary warfare exercises. 60

Table 18. Major training exercises and other training activities. 60

Table 19. Naval air systems command testing activities. 63

Table 20. Naval sea systems command testing activities. 65

Table 21. Description of Navy sonar source bins and comparison of annual activity levels by bin between ongoing activities and the proposed action. 66

Table 22. Acoustic sources that were not included in the Navy's quantitative analysis. 68

Table 23. Description of Navy explosive source bins and comparison of annual activity levels by bin between ongoing activities and the proposed action. 69

Table 24. Annual training activity levels under the proposed action compared to ongoing activity levels. 70

Table 25. Annual testing activity levels under the proposed action compared to ongoing activity levels. 81

Table 26. Environmental awareness and education. 90

Table 27. Procedural mitigation for active sonar. 91

Table 28. Procedural mitigation for weapons firing noise. 92

Table 29. Procedural mitigation for explosive sonobuoys. 93

Table 30. Procedural mitigation for explosive torpedoes. 96

Table 31. Procedural mitigation for explosive medium-caliber and large-caliber projectiles. 98

Table 32. Procedural mitigation for explosive missiles and rockets. 99

Table 33. Procedural mitigation for explosive bombs. 101

Table 34. Procedural mitigation for sinking exercises. 103

Table 35. Procedural mitigation for explosive mine countermeasure and neutralization activities. 104

Table 36. Procedural mitigation for explosive mine neutralization activities involving Navy divers. 106

Table 37.Procedural Mitigation for Maritime Security Operations – Anti-Swimmer Grenades 108

Table 38. Procedural mitigation for vessel movement. 109

Table 39. Procedural mitigation for towed in-water devices. 110

Table 40. Procedural mitigation for small-, medium-, and large-caliber non-explosive practice munitions. 112

Table 41. Procedural mitigation for non-explosive missiles and rockets. 113

Table 42. Procedural mitigation for non-explosive bombs and mine shapes. 115

Table 43. Proposed mitigation areas for seafloor resources. 117

Table 44. Proposed mitigation areas for marine mammals and sea turtles..... 120

Table 45. Summary of nearshore training and testing activities..... 134

Table 46. Typical air explosive munitions during Navy activities 141

Table 47. Representative aircraft sound characteristics (Navy 2018c)..... 144

Table 48. Sonic boom underwater sound levels modeled for supersonic flight from a representative aircraft. 146

Table 49. Examples of noise from weapons (Navy 2018b). 147

Table 50. Representative vessel types, lengths, and speeds (Navy 2018b). 151

Table 51. Size categories for decelerators/parachutes expended during training and testing activities (Navy 2018b). 156

Table 52. ESA-listed species that may be affected by the proposed action. 159

Table 53. Green sea turtle nesting abundance in each DPS (Seminoff et al. 2015). 193

Table 54. Reported Catch of Endangered Whales Considered in this Opinion, in the North Pacific Ocean. 249

Table 55. Catches taken in the Pacific Ocean by commercial, aboriginal, and scientific permit whaling since 1985[1]. 250

Table 56. Summary of major training exercises from 2015 to 2019. 251

Table 57. Summary of animal sightings during major training exercises. 251

Table 58. NMFS ESA effects determinations by stressor for each ESA-listed species, and overall effects determination for each species (LAA = likely to adversely affect; NLAA = not likely to adversely affect; NE = no effect)..... 264

Table 59. Range to PTS for five representative sonar systems (Navy 2018b). 362

Table 60. Ranges to TTS for sonar bin low frequency five (LF5) over a representative range of environments within the action area (Navy 2018b). 362

Table 61. Ranges to TTS for sonar bin mid-frequency one (MF1) over a representative range of environments within the action area (Navy 2018b). 363

Table 62. Ranges to TTS for sonar bin mid-frequency four (MF4) over a representative range of environments within the action area (Navy 2018b). 363

Table 63. Ranges to TTS for sonar bin mid-frequency five (MF5) over a representative range of environments within the action area (Navy 2018b). 363

Table 64. Ranges to TTS for sonar bin high frequency four (HF4) over a representative range of environments within the action area (Navy 2018b). 364

Table 65. Ranges to a potentially significant behavioral response for an example low frequency sonar bin (LF4) over a representative range of environments within the action area (Navy 2018b). 364

Table 66. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF1) over a representative range of environments within the action area (Navy 2018b). 365

Table 67. Ranges to potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF4) over a representative range of environments within the action area (Navy 2018b). 366

Table 68. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF5) over a representative range of environments within the action area (Navy 2018b). 366

Table 69. Ranges to a potentially significant behavioral response for an example high frequency sonar bin (i.e., HF4) over a representative range of environments within the action area (Navy 2018b). 367

Table 70. Unprocessed exposure estimates[1] of ESA-listed cetaceans to acoustic and explosive stressors. 369

Table 71. Estimated ESA-listed cetacean impacts (i.e., PTS, TTS, or significant behavioral disruption) per year from sonar and other transducers during training and testing activities. 370

Table 72. Preliminary yearly (2015–2019) estimates of abundance, including standard errors (SE) and 95% confidence intervals (CI), and densities of humpback whales in the Pacific Islands Fisheries Science Center's study area (Hill et al. 2020a). 378

Table 73. Estimated annual humpback whale takes within the GMAs and surrounding waters of Saipan, and estimated total annual humpback whale takes (all areas) reasonably certain to occur as a result of the proposed action. 379

Table 74. Ranges to non-auditory injury resulting from explosives for all cetacean hearing groups by Navy explosive bin (Navy 2018b). 404

Table 75. Ranges to mortality resulting from explosives for all cetacean hearing groups as a function of animal mass by Navy explosive bin (Navy 2018b). 405

Table 76. Sound exposure level based ranges to PTS, TTS, and behavioral response for low-frequency cetaceans (Navy 2018b). 406

Table 77. Peak pressure based ranges to PTS and TTS for low frequency cetaceans (Navy 2018b). 407

Table 78. SEL-based ranges to PTS, TTS, and behavioral disturbance for mid-frequency cetaceans (Navy 2018b). 408

Table 79. Peak pressure based ranges to PTS and TTS for mid-frequency cetaceans (Navy 2018b). 410

Table 80. Estimated ESA-listed cetacean impacts per year from explosives during training and testing activities. 412

Table 81. Estimated number of behavioral disruptions (i.e., TTS or significant behavioral response) from Navy sonar (and other transducers) and explosives per species/DPS in the action area. 421

Table 82. Estimated sea turtle impacts per year from MITT explosive activities. 427

Table 83. Range to effects (mortality and injury) from explosives for fish species in the action area (Navy 2019e). 443

Table 84. Estimated area of nearshore habitat impacted by ordnance at Farallon de Medinilla. 454

Table 85. The number of lethal and non-lethal takes of threatened and endangered cetaceans and sea turtles likely to occur annually* as a result of the proposed Navy training and testing activities in the action area. 500

LIST OF FIGURES

Page

Figure 1. Navy auditory weighting functions for marine mammal species groups. 30

Figure 2. TTS and PTS exposure functions for sonar and other acoustic sources for cetaceans (Navy 2018b). 31

Figure 3. Behavioral, TTS, and PTS exposure functions for explosives (Navy 2018b). 32

Figure 4. Behavioral response function for odontocetes (Navy 2017a). 36

Figure 5. Behavioral response function for mysticetes (Navy 2017a)..... 36

Figure 6. Auditory weighting function for sea turtles (Navy 2017). 38

Figure 7. TTS and PTS sea turtle exposure functions for sonar and other transducers (Navy 2017). 41

Figure 8. Spatially explicit density estimates used for sperm whale quantitative analyses (Navy 2019e). 44

Figure 9. Summer/fall distribution of green sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e)..... 46

Figure 10. Winter/spring distribution of green sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e)..... 47

Figure 11. Summer/fall distribution of hawksbill sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e)..... 48

Figure 12. Winter/spring distribution of hawksbill sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e)..... 49

Figure 13. Seafloor resource mitigation areas off Guam. 118

Figure 14. Seafloor resource mitigation areas off Tinian, Saipan, and Farallon de Medinilla. 119

Figure 15. Marine mammal and sea turtle MITT mitigation areas 122

Figure 16. Marpi Reef mitigation area and humpback whale sightings locations 123

Figure 17. Chalan Kanoa Reef mitigation area with sightings locations of humpback whales and sea turtles 124

Figure 18. Mariana Islands Training and Testing Action Area with the Mariana Islands Range Complex and notional transit corridor..... 127

Figure 19. Mariana Islands Range Complex Airspace 128

Figure 20. Farallon de Medinilla. 130

Figure 21. Farallon de Medinilla restricted area 7201, 7201A, and danger zone. 131

Figure 22. Tinian and Saipan 132

Figure 23. Rota. 133

Figure 24. MITT nearshore training and testing areas. 136

Figure 25. Apra Harbor Naval Complex (Main Base) and Main Base/Polaris Point. 137

Figure 26. Map identifying the range of the endangered blue whale. 165

Figure 27. Map identifying the range of the endangered fin whale. 171

Figure 28. Map identifying 14 DPSs with one threatened and four endangered, based on primary breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015). 175

Figure 29. Map identifying the range of the endangered sei whale. 183

Figure 30. Map identifying the range of the endangered sperm whale. 187

Figure 31. Map depicting range and DPS boundaries for green turtles. 192

Figure 32. Nesting distribution of green turtles in the East Indian-West Pacific DPS (water body labeled ‘6’). Size of circles indicates estimated nester abundance. Locations marked with an ‘x’ indicate sites lacking abundance information (Seminoff et al. 2015). 195

Figure 33. Nesting distribution of green turtles in the Central West Pacific DPS (water body labeled ‘7’). Size of circles indicates estimated nester abundance. Locations marked with an ‘x’ indicate sites lacking abundance information (Seminoff et al. 2015). 196

Figure 34. Nesting distribution of green turtles in the Central North Pacific DPS (water body labeled ‘10’). Size of circles indicates estimated nester abundance (Seminoff et al. 2015). 197

Figure 35. Habitat use map for green sea turtles on Guam (cite Navy BA) 200

Figure 36. Map identifying the range of the endangered hawksbill sea turtle. 202

Figure 37. Map identifying the range of the leatherback sea turtle with the seven subpopulations and nesting sites. Adapted from (Wallace et al. 2010). 206

Figure 38. Map identifying the range and DPS boundaries of the loggerhead sea turtle. 212

Figure 39. Map depicting the DPSs for the scalloped hammerhead shark. 217

Figure 40. Map depicting the range of the giant manta ray [adapted from Lawson et al. (2017)] 220

Figure 41. Geographic range of the oceanic whitetip shark [adapted from Last and Stevens (2009)]. 224

Figure 42. *Acropora globiceps* distribution. Off-white = no record, dark green = confirmed record, pale green = predicted record, tan = published record that needs further investigation (Veron 2014). 227

Figure 43: Juvenile hawksbill turtle entangled in marine debris recovered in Garapan Lagoon, Saipan, December 2013. Image: CNMI Department of Lands & Natural Resources. 244

Figure 44: Evidence of attempted poaching in the CNMI: A live juvenile green turtle found flipper-bound by a rubber strap, Saipan, 13 February 2014. Image courtesy of CNMI Department of Lands & Natural Resources. 247

Figure 45. Apra Harbor, July 1945. The yellow line indicates the approximate shoreline prior to the dredging and fill projects of the 1940s. 254

Figure 46: Shipping lanes in the action area. 256

Figure 47: Two hypothetical threshold shifts. 339

Figure 48. MITT geographic naming conventions used for NAEMO estimated impacts by region (Navy 2019e). 371

Figure 49. Blue whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action. 372

Figure 50. Fin Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action. 372

Figure 51. Humpback Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action. 373

Figure 52. Sei Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action. 373

Figure 53. Sperm Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action. 374

Figure 54. Pacific Islands Fisheries Science Center's (PIFSC) survey tracklines (gray lines) and humpback whale encounter locations (red dots) during winter (January–March) surveys 2015–2019. A minimum convex polygon (MCP; solid black line; 839 km2) was created to delineate the (PIFSC) survey area for estimating yearly (2015–2019) density of non-calf humpback whales within the survey area. The MCP was truncated (red dashed line; 384 km^2) to include only

the areas off the west side of Saipan to Chalan Kanoa Reef (CK) and north to Marpi Reef where most of the survey effort and all of the humpback whale encounters occurred. 377

Figure 55. Humpback whale impacts estimated per year from the maximum number of explosions during training and testing under the proposed action. 412

Figure 56. Sei whale impacts estimated per year from the maximum number of explosions during training and testing under the proposed action. 413

Figure 57. Underwater Detonation and Mine Neutralization Sites in and around Apra Harbor, Guam 452

Figure 58. Location of *Acropora globiceps* in Relation to FDM Impact Areas. 457

Figure 59. Confirmed and Suspected Locations of *Acropora globiceps* in Relation to FDM Impact Areas 2 and 3. 458

1 INTRODUCTION

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

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

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, in accordance with the ESA Subsection 7(b)(3(A), NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures considered necessary and appropriate to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. NMFS, by regulation, has determined that an ITS must be prepared when take is "reasonably certain to occur" as a result of the proposed action (50 C.F.R. 402.14(g)(7)). Where incidental take to ESA-listed species of marine mammals is reasonably certain to occur, the ITS must specify those measures that are necessary to comply with the Marine Mammal Protection Act (MMPA) authorization issued pursuant to section 101(a)(5), 16 U.S.C. §1371(a)(5). Pursuant to ESA Section 7(o), incidental take caused by the proposed action and occurring consistent with the ITS, including its specified reasonable and prudent measures and implementing terms and conditions, is exempted from the ESA Section 9's prohibition on the take of endangered species and threatened species to which such prohibition has been extended by regulation.

The action agencies for this consultation are the United States (U.S.) Department of the Navy (Navy)[1], which undertakes military training and testing activities and NMFS's Office of Protected Resources, Permits and Conservation Division (Permits Division), which (1) promulgated regulations under the MMPA governing the U.S. Navy's "take" of marine mammals incidental to those military readiness activities which are in effect from August 2020 through August 2027 and (2) issued a Letter of Authorization (LOA) pursuant to the regulations that authorizes the U.S. Navy to "take" marine mammals incidental to those military readiness activities through August 2027.

This consultation, opinion, and ITS, were completed in accordance with sections 7(a)(2) and 7(b) of the statute (16 U.S.C. §§1536 (a)(2), 1536(b)), associated implementing regulations (50 C.F.R. Part 402), and agency policy and guidance by NMFS Office of Protected Resources ESA Interagency Cooperation Division (hereafter referred to as "we" or "us"). This opinion and ITS were prepared by us in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402 and specifically 50 C.F.R. §402. 14. This opinion reflects the best available scientific information and data on the status and life history of ESA-listed species, the stressors resulting from the proposed action, the likely effects of those stressors on ESA-listed species and their habitats, the consequences of those effects to the fitness and survival of individuals, and the risk that those consequences pose to the survival and recovery of the threatened or endangered populations they represent.

Updates to the regulations governing interagency consultation (50 C.F.R. part 402) were effective on October 28, 2019 [84 FR 44976]. This consultation was pending at that time, and we are applying the updated regulations to the consultation. As the preamble to the final rule adopting the regulations noted, "[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." We have reviewed the information and analyses relied upon to complete this biological opinion (opinion) in light of the updated regulations and conclude the opinion is fully consistent with the updated regulations including, among others, the revised provisions addressing: effects of the action, the environmental baseline, consideration of beneficial measures, and destruction and adverse modification of critical habitat.

This document represents our opinion on the effects of the Navy's proposed Mariana Islands Training and Testing (MITT) activities and the Permits Division's promulgation of regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to MITT activities on

[1]The Navy is the executive agent for Mariana Islands Training and Testing (MITT) activities which include all Navy, US Air Force (USAF), and US Coast Guard (USCG) activities as outlined in the Navy's 2019 MITT Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). This biological opinion supports Navy, USAF, and USCG actions.

endangered and threatened species and critical habitat that has been designated for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The Navy proposes to conduct training and testing activities within the MITT Study Area (hereafter referred to as the "Action Area") starting in August 2020 and continuing into the reasonably foreseeable future. These activities are hereafter referred to as "Phase III" activities. Navy training and testing activities have been ongoing in this same general geographic area for several decades and as indicated below, many of these activities have been considered in previous ESA section 7 consultations (i.e., as detailed below, in consultations that considered Phase I and Phase II Navy actions).

On June 12, 2015, NMFS issued a final biological opinion and conference report on the Navy's proposed action to conduct MITT Phase II activities and the NMFS's promulgation of regulations and issuance of a LOA pursuant to the MMPA for the Navy to "take" marine mammals incidental to MITT activities from August 2015 through August 2020 (NMFS 2015b). Revisions to the 2015 opinion were subsequently required and the section 7 consultation was reinitiated to address the following: 1) analysis of impacts to green sea turtles in consideration of the final rule, issued in 2016, to list 11 Distinct Population Segments (DPSs) of green sea turtles as threatened or endangered under the ESA (81 FR 20057); 2) analysis of humpback whales in consideration of the final rule, issued in 2016, to divide the globally-listed humpback whale into 14 DPSs and list four DPSs as endangered and one as threatened (81 FR 62259); and 3) new scientific information provided by the Navy on coral coverage at Farallon de Medinilla (FDM). NMFS completed the reinitiated formal consultation and, on September 13, 2017 NMFS issued a revised opinion (NMFS 2017c) for MITT Phase II that superseded the 2015 opinion.

1.2 Endangered Species Act (ESA) Consultation History

On April 2, 2019, the Navy and NMFS held a conference call to discuss the format and content of the Navy's MITT Phase III Biological Assessment (BA). During the call the Navy proposed that this consultation be considered a reinitiation of ESA section 7 consultation on MITT Phase II instead of a new, full consultation.

From April 3 – April 29, 2019, the Navy responded to several requests for information from NMFS. Requested information included survey monitoring reports for the MITT Action Area, species density technical reports and derivation, vessel movement and activity, sea turtle research, and sea turtle and marine mammal strandings information.

On April 11, 2019, the Navy sent us a draft BA for review.

On April 29, 2019, we sent the Navy a letter with initial feedback on the Navy's BA and addressing the Navy's proposal to conduct Phase III as a reinitiation of the current consultation. In the letter we requested that the Navy submit the MITT Phase III initiation package as a new

consultation and not as a reinitiation because a complete analysis incorporating all changes and new information had not been conducted since 2015, and the interrelated NMFS MMPA action is an entirely new action that cannot be consulted on as a reinitiation.

On May 8, 2019, we completed our review of the draft BA and provided comments and suggested edits to the Navy.

On June 12, 2019, NMFS (Permits Division and Interagency Cooperation Division) sent the Navy an email requesting either a year-round restriction on mid-frequency active sonar (MFAS) or, at a minimum, a seasonal restriction on MFAS from December through April within the established Chalan Kanoa and Marpi Reef humpback geographic mitigation areas (GMAs). These GMAs were established by the Navy and discussed in their BA.

On June 20, 2019, the Navy submitted to us a revised BA and requested initiation of formal consultation in accordance with section 7 of the ESA.

On June 26, 2019, we responded to the Navy requesting additional information. NMFS and the Navy held a conference call on July 3, 2019 to discuss the additional information we were requesting from the Navy. We also requested that the Navy consider additional procedural mitigation measures for giant manta rays and oceanic whitetip sharks.

On July 15, 2019, the Navy responded to NMFS regarding additional mitigation measures. The Navy agreed to add giant manta ray procedural mitigation for explosive mine neutralization activities involving Navy divers. The Navy pointed out that given the more open ocean, pelagic nature of oceanic whitetip sharks, this species would be less likely to co-occur with the coastal and nearshore diver activities.

On July 16, 2019, NMFS and the Navy held a conference call to discuss the MITT ESA section 7 consultation and the MMPA proposed rule. Topics included cetacean ship strike analysis, expansion of humpback whale mitigation areas, additional restrictions on sonar in mitigation areas, seasonal awareness message for humpback whales in mitigation areas, and additional mitigation for recently listed elasmobranchs.

On July 31, 2019, the Navy submitted a revised BA to us. In the revised BA the Navy proposed to expand the spatial scale of both humpback mitigation areas (Marpi Reef, Chalan Kanoa Reef) to encompass the 400-meter depth contour, to add a seasonal awareness message for humpback whales in those mitigation areas, and to add manta rays to the procedural mitigation for explosive mine neutralization activities involving Navy divers.

On August 2, 2019, we responded to the Navy indicating that the version of the BA submitted on July 31, 2019 (Navy 2019e) was complete. We also indicated that during the consultation process additional information may be requested and additional measures may be proposed to the Navy to minimize impacts to ESA-listed resources based on our effects analyses. Because the Navy's proposed action is interrelated with the NMFS Permits Division’s proposed issuance of

regulations in accordance with the MMPA, initiation of formal consultation would commence once we receive and accept as complete the NMFS Permits Division's initiation package.

On August 27, 2019, NMFS emailed the Navy requesting an estimate of the number of hours of MFAS sonar within the GMAs. The Navy response included some additional information on the estimated proportion of these hours by season (e.g., half in cold and half in warm for modeling purposes) and proportion of modeled impacts by area (e.g., 35 percent within the MIRC), but did not provide the requested estimate of the annual number of hours of MFAS sonar that would likely occur in the GMAs, or in shallower water littoral areas in general. The Navy's memo concluded that the probability of MFAS within the GMAs is very low.

On October 17, 2019, in an email to the Navy, NMFS requested language revisions to the Navy's proposed Procedural Mitigation for Explosive Mine Neutralization Activities Involving Navy Divers. In particular, NMFS was concerned that the term "detonation location" had not been defined and suggested either defining or replacing with "mitigation zone." On October 28, after several rounds of revisions exchanged through emails, NMFS and the Navy agreed on a revised version of this procedural mitigation.

On November 20, 2019, NMFS staff participated in the Navy's MITT Supplemental Final EIS/OEIS V1 Tiger Team Review held in Arlington, Virginia. Agenda items included: Navy comments and responses of interest to NFMS for MITT draft FEIS; humpback whale geographic mitigation areas; MITT schedule; and other issues related to the MITT draft biological opinion and MMPA proposed rule.

On November 27, 2019, the Navy sent NMFS comments regarding the terms and conditions associated with the ongoing MITT Phase II biological opinion to help inform discussion of pending terms and conditions for the Phase III consultation.

On January 13, 2020, we sent the action agencies (Navy and NMFS Permits Division) a draft biological opinion for review.

On January 30, 2020, the Navy completed its review of the draft biological opinion and provided NFMS with comments and suggested edits.

On February 7, 2020, the NMFS Permits Division sent us a memo requesting initiation of formal ESA section 7 consultation on its proposal to issue regulations and subsequent LOA to the Navy to incidentally take marine mammals during MITT Phase III activities.

On February 24, 2020, we sent the NMFS Permits Division a memo indicating that we had sufficient information to initiate formal section 7 consultation. The official initiation date was February 11, 2020.

On February 25, 2020 we mailed a letter to the Navy indicating that we had initiated section 7 consultation on NWTT as of February 11, 2020. An Email was also sent on this day with a copy of the letter.

On April 8, 2020, the Navy sent NMFS a memo responding to several public comments on the proposed MMPA rule and other unresolved issues. As part of this memo, the Navy indicated that a seasonal restriction on MFAS within the humpback whale GMAs is not practicable for the Navy. As an alternative mitigation measure the Navy proposed a seasonal MFAS cap between December and April with sonar use not to exceed more than 40 hours of hull-mounted surface ship mid-frequency active sonar (MF1) for both GMAs combined.

On April 10, 2020, NMFS (Permits Division and Interagency Cooperation Division) sent the Navy a memo regarding NMFS' position on the humpback whale mitigation in the MITT action area. The memo provided additional information and further support for NMFS' position that a seasonal restriction on MFAS in the GMAs (see June 12, 2019 above) is both necessary for the conservation of Western North Pacific DPS humpback whales and practicable for the Navy to implement.

On April 10, 2020, NMFS and the Navy held a conference call to discuss the use of MFAS in the GMAs, as well as other MITT mitigation related issues. This call did not result in a mutually agreed to path forward regarding the issue of MFAS use within the humpback whales GMAs from December through April.

On May 7, 2020, the Navy sent NMFS a memo with a revised proposal for mitigation within the GMAs (Navy 2020b). The Navy proposed a 20 hour seasonal cap from December through April on MF1 sonar applicable for both GMAs (i.e., Chalan Kanoa Reef and Marpi Reef) combined. The Navy also agreed to annual classified reporting of all sonar use (all bins, by bin) within the GMAs. The Navy's memo also provided additional information on the importance of available shallow water habitat in MITT, and particularly of areas within the GMAs, for anti-submarine warfare training.

On May 13, 2020, NMFS' Interagency Cooperation Division and the Navy met to discuss whether the proposed 20 hour seasonal cap represented in a change in the Navy's proposed action. NMFS stated that a 20 hour cap was not a conservation measure based on an analysis of past sonar use and current needs for sonar use in the GMAs based on information provided by the Navy in their BA and subsequent correspondence. NMFS requested additional information from the Navy regarding estimated take of humpback whales in the two proposed GMAs with a potential use of 20 hours of MF1 sonar. On May 15, 2020, the Navy sent NMFS a memo with their updated humpback whales effects analysis.

On May 22, 2020, NMFS sent an Email to the Navy requesting additional details on the Navy's proposed use of MF1 sonar in the GMAs, including whether the 20 hour cap was a maximum year or a representative year of sonar use. In a memo dated May 28, 2020, the Navy responded

with additional information and indicated that 20 hours represented the maximum level of sonar use within the GMAs from December through April. The Navy also indicated that they could not provide NMFS with an estimate of the number of hours in a representative (or typical) year of sonar use in the GMAs. Based on the information provided by the Navy, we accepted the 20 hour maximum use as a clarification of the proposed action described in the BA and evaluated the effects of 20 hours of MF1 sonar within the GMAs from December through April on annual basis for our humpback whale effects analysis (see Section 8.2.1 below).

From June 5-11, 2020, the Navy sent NMFS additional information regarding the potential impacts of MF1 sonar on humpback whales (mother-calf pairs in particular) within the GMAs. This included the Navy's quantitative analysis (based on NAEMO) of the risk of humpback whale sonar exposure resulting in PTS.

On July 2, 2020, NMFS sent the Navy the following sections of the draft opinion for review and comment: 1) complete draft of the Incidental Take Statement, 2) Conservation Recommendations, and 3) excerpts from the opinion discussing the Navy's proposed 20 hour seasonal cap on MF1 sonar in the humpback whale GMAs. The Navy provided their comments to NMFS on July 6, 2020.

2 THE ASSESSMENT FRAMEWORK

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

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

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of an ESA-listed species (50 C.F.R. §402.02).

An ESA section 7 assessment involves the following steps:

1) We describe the proposed action (Section 3) and the action area (Section 4) related to the proposed action.
2) We deconstruct the action into the activities such that we can identify those aspects of the proposed action that are likely to create pathways for impacts to ESA-listed species or designated critical habitat. These pathways or "stressors" may result in effects on the physical, chemical, and biotic environment within the action area. We also consider the spatial and temporal extent of those stressors (Section 6).
3) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time (Section 6). During consultation, we determined that some ESA-listed species and designated critical habitat that occur in the action area were not likely to be adversely affected by the proposed action. We summarize our findings and do not carry those species forward in this opinion as species cannot be jeopardized and critical habitat cannot be adversely modified or destroyed in the absence of adverse effects to individuals (Section 7.1). We then describe the status of those species and critical habitats that are likely to be adversely affected (Section 7.2).
4) We describe the environmental baseline in the action area (Section 8). 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 consequences to listed species or designated critical habitat from ongoing agency activities or existing agency

facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02).

5) We evaluate the effects of the action on ESA-listed species and designated critical habitat (Section 9).
   a) During our evaluation, we determined that some stressors were not likely to adversely affect some ESA-listed species, designated critical habitats or categories of ESA-listed species (Section 8.1). The stressors that we determined are likely to adversely affect ESA-listed species or critical habitat were carried forward for additional analysis (Section 8.2).
   b) For those stressors likely to adversely affect ESA-listed species, we identify the number, age (or life stage), and gender if possible and if needed, of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. This is our exposure analysis.
   c) We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analyses.
   d) The adverse effects analysis for critical habitat considers the impacts of the proposed action on the essential habitat features and conservation value of designated critical habitat within the action area, and the adverse modification analysis considers these effects on designated critical habitat as a whole using the same exposure, response, and risk framework.
6) We describe any cumulative effects of the proposed action in the action area (Section 9).
7) We integrate and synthesize the above factors (Section 10) by adding the effects of the action and cumulative effects to the environmental baseline and in light of the status of the species and critical habitat, formulate the Service's opinion as to whether the action would reasonably be expected to:
   a) Reduce appreciably the likelihood of both survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution (i.e. jeopardy); or
   b) Reduce the conservation value of designated or proposed critical habitat (i.e. destruction or adverse modification of critical habitat).
8) We state our conclusions regarding whether the action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat (Section 11).

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative(s) to the action

that would allow the action to proceed in compliance with ESA section 7(a)(2). The reasonable and prudent alternative also must meet other regulatory requirements.

If incidental take of ESA-listed species is expected, section 7(b)(4) of the ESA requires that we provide an ITS that specifies the amount or extent of take, the impact of the take, necessary or appropriate reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures (ESA section 7 (b)(4); 50 C.F.R. §402.14(i); Section 12). Where incidental take to ESA-listed species of marine mammals is reasonably certain to occur, the ITS must specify those measures that are necessary to comply with any MMPA authorization issued pursuant to 16 U.S.C. §1371(a)(5). ESA section (7)(o)(2) provides that compliance by the action agency with the terms and conditions exempts any incidental take from the prohibitions of take in ESA section 9(b) and regulations issued pursuant to ESA section 4(d).

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

Pursuant to the ESA, Section 7(a)(1) and its implementing regulations, we also provide discretionary conservation recommendations that may be implemented by the action agency (Section 13; 50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which reinitiation of formal consultation is required (Section 14; 50 C.F.R. §402.16).

As discussed in the Section 1.2 *ESA Consultation History*, one particular part of the proposed action that we discussed at length with the action agencies and conducted a detailed effects analysis on was the proposed use of sonar within identified humpback whale breeding and calving grounds around Saipan. Sections of this opinion relevant to this issue include the following: Section 6.2.3 *Humpback Whale Western North Pacific DPS* (status of the species); Section 8.2.1., see *Exposure Analysis for Humpback Whales within the GMAs;* Section 8.2.1., see *Humpback Mother-Calf Pair Responses to Sonar on the Breeding Grounds*; and Section 10.1.3 *Humpback Whale Western North Pacific DPS* (Integration and Synthesis).

2.1 Evidence Available for this Consultation

To conduct these analyses and to comply with our obligation to use the best scientific and commercial data available, we considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. We conducted electronic literature searches throughout this consultation, including within NMFS Office of Protected Resource's electronic library. We examined the Navy's BA (Navy 2019e), the Navy's DEIS and FEIS (Navy 2019d), the literature that was cited in the Navy's BA and FEIS, and any articles we collected through our electronic searches. We also evaluated the Navy's annual and comprehensive monitoring reports required under the existing MMPA rule and LOAs and the previous biological opinion for current training and testing activities occurring in the same geographic area. These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species. In addition, we engage regularly with the Navy to discuss new science and technical issues as part of the ongoing adaptive management program for Navy training and testing and incorporate new information obtained as a result of these engagements in this consultation.

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

The sections below discuss NMFS' approach to analyzing the effects of sound produced by Navy training and testing activities in the MITT action area on ESA-listed marine mammals, sea turtles, and fish. The estimates of the number of ESA-listed marine mammals and sea turtles exposed to sound from Navy training and testing, as well as the magnitude of effect from each exposures (e.g., injury, hearing loss, behavioral response), are from the Navy's acoustic effects analysis described in detail in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018d). NMFS considers the modeling conclusions from the Navy's analysis to represent the best available science and data on exposure of marine mammals and sea turtles to acoustic

stressors from the proposed action.[2] NMFS' analysis of the effects of and potential consequences of such exposures is included in Section 9 of this opinion.

2.2 Acoustic Effects Analysis

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars), as well as incidental sources of broadband sound produced as a byproduct of vessel movement, aircraft transits, pile driving and removal, and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique energetic characteristics. To estimate impacts from acoustic stressors associated with proposed training and testing activities, the Navy performed a quantitative analysis to estimate the number of instances that could affect ESA-listed marine mammals and sea turtles and the magnitude of that effect (e.g., injury, hearing loss, behavioral response). The quantitative analysis utilizes the Navy's Acoustic Effects Model (NAEMO) and takes into account criteria and thresholds used to predict impacts in conjunction with spatial densities of species within the action area.

A summary of the quantitative analysis is provided below. A more detailed explanation of this analysis is in the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018d). NMFS verified the methodology and data used by the Navy in this analysis and unless otherwise specified in Section 8 of this opinion, accepted the modeling conclusions on exposure of marine mammals and sea turtles to sound generated by the proposed action. NMFS considers the modeling conclusions from the Navy's analysis to represent the best available data on exposure of marine mammals and sea turtles to acoustic stressors from the proposed action and the estimates of take resulting from this analysis are reasonably certain to occur.

2.2.1 Navy Acoustic Effects Model and Post-Processing Model Outputs

NAEMO calculates sound energy propagation from sonars and other transducers (as well as explosives) during naval activities and the sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals and sea turtles distributed in the area around the modeled naval activity. Each of the animat dosimeters records its individual sound "dose." The model bases the distribution of animats over the action area on the density values (See Section 2.2.6 below) in the Navy Marine Species Density Database (Navy 2018e) and distributes animats in the water column proportional to the known time that species spend at varying depths.

Physical environment data plays an important role in acoustic propagation of underwater sound sources used in the impact modeling process (Navy 2019e). Physical environment parameters that influence propagation modeling include bathymetry, seafloor composition/sediment type,

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

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 or sea turtles could be affected by the aspects of the proposed activity that generate sound.

Marine mammal and sea turtle data input to the NAEMO include densities (discussed below), group size, depth distribution, and guild and stock breakouts (Navy 2019e). Since 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 accounts for depth distributions by changing each animat's depth 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 within various depth bins in the water column. In some cases, sea turtle sightings data used in the density database are ambiguous regarding species classification and a density can only be reported as a group of similar species, or "guilds." The proportion of each sea turtle species within each guild is estimated based on sightings where species could be determined. Based on these proportions, predicted impacts on guilds are separated out to the species level. Similarly, many marine mammal species are divided into multiple stocks based on life history and genetic stock structure for management purposes. For some stocks there is enough survey information to support stock-specific density models. In these cases, a density layer for the stock is provided and is modeled independently of other stocks. In other cases, predicted impacts were assigned by stock, as opposed to the species as a whole (Navy 2019e).

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

As described further in Section 3.6.2, the Navy proposes to implement a series of procedural mitigation measures designed to minimize or avoid potentially injurious impacts on marine mammals and sea turtles. The Navy implements mitigation measures during training and testing activities when a marine mammal or sea turtle is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to injury for sonar sources and much of the range to injury

for explosives. The Navy designed the mitigation zones for most acoustic and explosive stressors according to its source bins. Sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose of use. Classes are further sorted by bins based on the frequency or bandwidth, source level, and when warranted, the application in which the source would be used. Explosives detonated in water are binned by net explosive weight (NEW). Mitigation does not pertain to stressors that would have no effect on an ESA-listed species (e.g., acoustic and explosive sources that do not have the potential to impact ESA-listed marine mammals or sea turtles).

NAEMO does not take into account mitigation measures or animal avoidance behavior when predicting impacts to marine mammals and sea turtles from acoustic stressors. Therefore, to account for mitigation measures to minimize potential exposures and effects on marine mammals and sea turtles, the Navy quantified the potential for mitigation to reduce model-estimated permanent threshold shift (PTS) to temporary threshold shift (TTS) in hearing for exposures to sonar and other transducers, and to reduce model-estimated mortality due to injury from exposures to explosives. Mitigation effectiveness is quantitatively assessed on a per-scenario basis using four factors: species sightability, observation area, visibility, and positive control of the sound source. Observation area refers to the extent to which the type of mitigation proposed for a sound producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity. Sightability of each species that may be present in the mitigation zone is determined by species-specific characteristics and the viewing platform. Positive control of the sound source is based on the ability to shut down the source in a timely manner to mitigate impacts. Considering these factors, only a portion of injurious exposures are considered mitigable. In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, some model-estimated PTS is considered mitigated to the level of TTS. The impact analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species in the vicinity of animals sighted at the ocean surface within the mitigation zone.

The Navy estimated the ability of Navy Lookouts to observe the range to PTS for each training or testing event. The ability of Navy Lookouts to detect protected species in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. For example, based on small boat surveys between 2000 and 2012 in the Hawaiian Islands, pantropical spotted dolphins and striped dolphins were frequently observed leaping out of the water, and Cuvier's beaked whales and Blainville's beaked whales were occasionally observed breaching (Navy 2019e). These behaviors are visible from a great distance and likely increase sighting distances

and detections of these species. Environmental conditions under which the training or testing activity could take place are also considered, such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

To consider the benefits of procedural mitigation to marine mammals and sea turtles within the ESA exposure estimates, the Navy factored mitigation effectiveness into its quantitative analysis process. The Navy's quantitative analysis assumes Lookouts will not be 100 percent effective at detecting all individual marine mammals and sea turtles within the mitigation zones for each activity. This is due to the inherent limitations of observing marine species and because the likelihood of sighting individual animals is largely dependent on observation conditions (e.g., time of day, sea state, mitigation zone size, observation platform) and animal behavior (e.g., the amount of time an animal spends at the surface of the water). This is particularly true for sea turtles, small marine mammals, and marine mammals that display cryptic behaviors (e.g., surfacing to breathe with only a small portion of their body visible from the surface). Discussions about the likelihood that a Lookout would observe a marine mammal or sea turtle pertain specifically to animals that are available to be observed (i.e., on, above, or just below the water's surface). The benefits of procedural mitigation measures for species that were not included in the quantitative analysis process (i.e., fish) are discussed qualitatively.

The Navy's quantitative analysis takes into account and quantifies the potential for animals to actively avoid potentially injurious sound sources. Marine mammals and sea turtles often avoid loud sound sources (e.g., those that could be injurious). Because marine mammals and sea turtles are assumed to initiate avoidance behavior when exposed to relatively high received levels of sound within their capacity to detect, an exposed animal could reduce its cumulative sound energy exposure from something like a sonar event with multiple pings (i.e., accumulated sound exposures) by leaving the area. This would reduce risk of both PTS and TTS, although the quantitative analysis only considers the potential to reduce instances of PTS by accounting for marine mammals or sea turtles swimming away to avoid repeated high-level sound exposures. All reductions in PTS sonar impacts from likely avoidance behaviors are considered TTS impacts. The following discussion from the Navy's acoustic effects analysis technical report explains how PTS takes are quantitatively reduced to TTS based on avoidance factors: "Animals present beyond the range to onset PTS for the first three to four pings are assumed to avoid any additional exposures at levels that could cause PTS. This equates to approximately 5 percent of the total pings or 5 percent of the overall time active; therefore, 95 percent of marine mammals predicted to experience PTS due to sonar and other transducers are instead assumed to experience TTS" (Navy 2018d).

The Navy's consideration of mitigation and avoidance to reduce the number of ESA-listed animals exposed to sonar or explosives is termed "post-processing" of the NAEMO model outputs. A full description of this process is described in the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018d).

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

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

The Navy, in coordination with the NMFS, established acoustic thresholds (for impulsive, non-impulsive sounds and explosives) using the best available science that identifies the received level of underwater sound above which exposed marine mammals would reasonably be expected to experience a potentially significant disruption in behavior, or to incur TTS or PTS of some degree. Thresholds have also been developed to identify the pressure levels above which animals may incur different types of tissue damage from exposure to pressure waves from explosive detonation. A detailed description of the criteria and threshold development is included in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a). The thresholds used by the Navy were developed by compiling and synthesizing the best available science on the susceptibility of marine mammals and sea turtles to effects from acoustic exposure. Recent marine mammal behavioral studies have resulted in the development of new behavioral response functions for predicting alterations in behavior. Additional information on auditory weighting functions has also emerged (Mulsow et al. 2015), leading to a new methodology to predict auditory weighting functions for each hearing group along with the accompanying hearing loss thresholds. Criteria for predicting hearing loss were documented in NMFS' *2016 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals Hearing* (NOAA 2016), and reaffirmed in the 2018 revision of this document (NMFS 2018a).

Marine Mammal Criteria for Hearing Impairment, Non-Auditory Injury, and Mortality
The marine mammal criteria and thresholds for non-impulsive and impulsive sources for hearing impairment, non-auditory injury, and mortality, as applicable, are described below. The Navy's quantitative acoustic effects analysis used dual criteria to assess auditory injury (i.e., PTS) to different marine mammal groups (based on hearing sensitivity) as a result of exposure to impulsive sources (i.e., explosives, air guns, impact pile driving). The Navy's quantitative analysis of TTS/PTS for non-impulsive (i.e., sonar, vibratory pile driving) sources used SEL only. Although air guns and pile driving are not used during MITT training and testing activities, the analysis of some explosive impacts (Section 8.2) will, in part, rely on information from exposure to these impulsive sources, where appropriate. The criteria used in the analysis are described in *NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018).

The Navy used auditory weighting functions and weighted thresholds to assess the varying susceptibility of marine mammals to effects from noise exposure. Animals are not equally

sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions were used (Figure 1). Auditory weighting functions are mathematical functions that adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges with less or no auditory sensitivity. They incorporate species-specific hearing abilities to calculate a weighted received sound level in units such as sound pressure level (SPL) or sound exposure level (SEL). Auditory weighting functions resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range, while the frequencies below and above this range (where amplitude declines) are de-emphasized. For non-impulsive sources, the TTS and PTS exposure functions for marine mammals are presented in Figure 2. The weighted thresholds for cetaceans for non-impulsive acoustic sources are summarized in Table 1.

For impulsive sources (including explosives, air guns, and impact pile driving), the TTS and PTS exposure functions for marine mammals are presented in Figure 3.[3] Based on the exposure functions, the cetacean onset TTS and PTS thresholds for impulsive sources are described in Table 2.

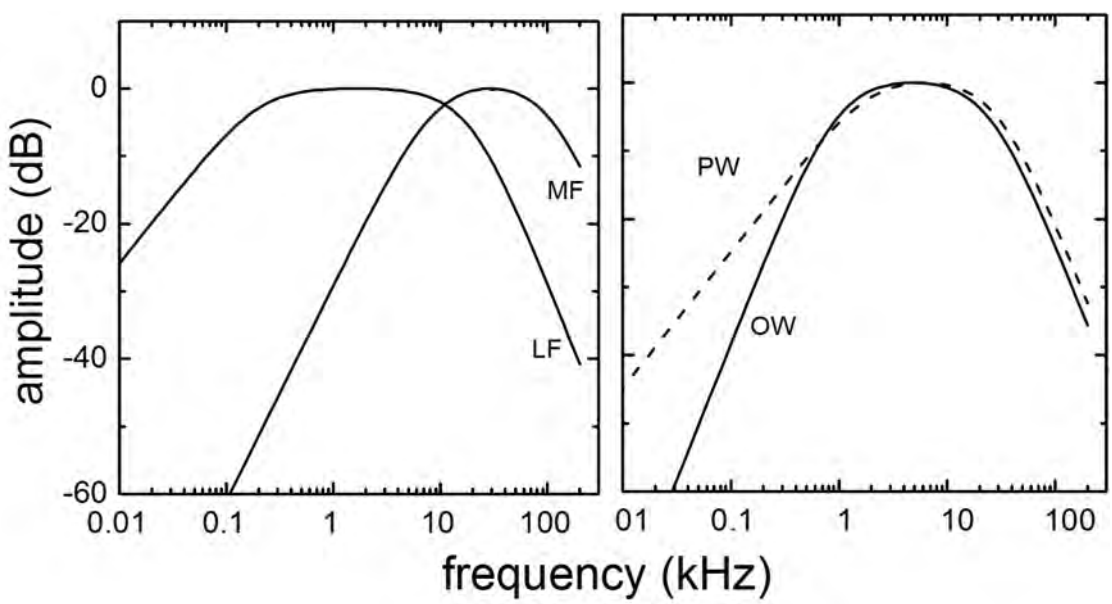
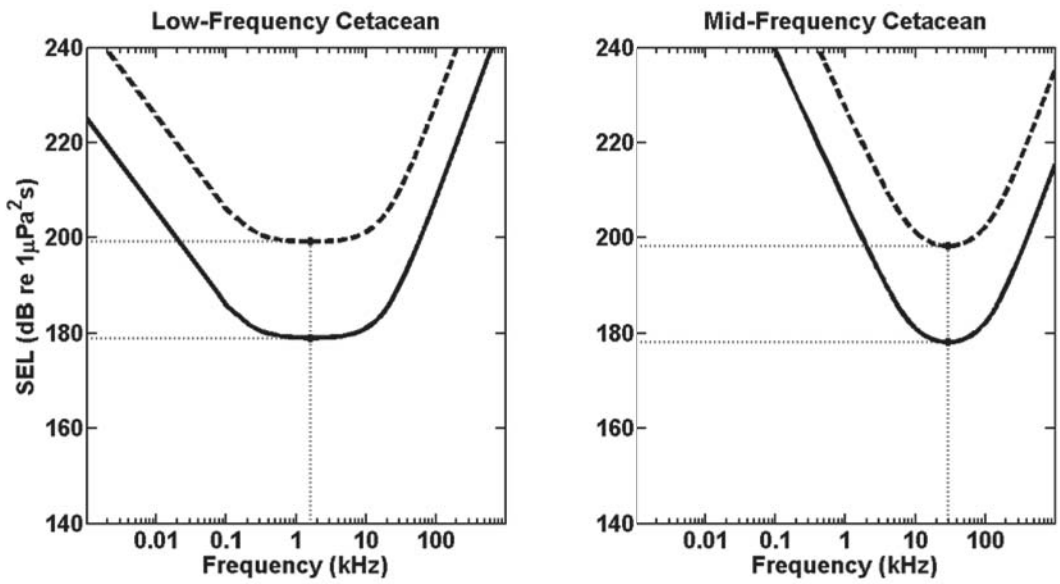


Figure 1. Navy auditory weighting functions for marine mammal species groups.

Note. LF = Low-Frequency Cetacean, MF = Mid-Frequency Cetacean, PW = Phocid, OW = Otariid (In-water).

[3] Note that this figure also depicts the marine mammal exposure functions for behavioral response from explosives.



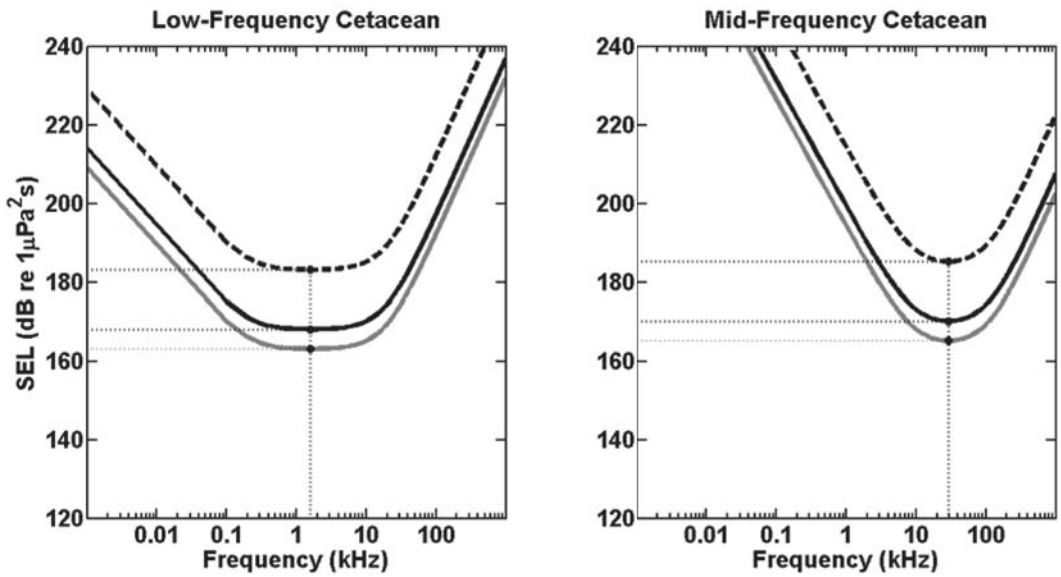
Note: Solid curve is the exposure function for TTS onset; dashed curve is the exposure function for PTS onset. Small dashed lines indicate the sound exposure level threshold for TTS and PTS onset in frequency range of best hearing.

Figure 2. TTS and PTS exposure functions for sonar and other acoustic sources for cetaceans (Navy 2018b).

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

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

Note: SEL thresholds in decibels (dB) re 1 μPa²s (decibels referenced to 1 micropascal).



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

Figure 3. Behavioral, TTS, and PTS exposure functions for explosives (Navy 2018b).

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

Functional Hearing Group	Species	Onset TTS	Onset PTS
Low-frequency cetaceans	All mysticetes	168 dB SEL (weighted) or 213 dB Peak SPL (unweighted)	183 dB SEL (weighted) or 219 dB Peak SPL (unweighted)
Mid-frequency cetaceans	All odontocetes	170 dB SEL (weighted) or 224 dB Peak SPL (unweighted)	185 dB SEL (weighted) or 230 dB Peak SPL (unweighted)

Unlike the other acoustic sources proposed for use by the Navy, explosives also have the potential to result in non-auditory injury or mortality. Two metrics have been identified as predictive of injury: impulse and peak pressure. The exposure thresholds are used to estimate the number of animals that may be affected during Navy training and testing activities (see second column of Table 3). The thresholds for the farthest range to effect are based on the received level at which one percent risk is predicted and are useful for informing mitigation zones (see third column of Table 3). Increasing animal mass and increasing animal depth both increase the

impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). For masses used in impact assessment, marine mammal populations are assumed to be 70 percent adult and 30 percent calf/pup. The derivation of these injury criteria and the species mass estimates are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017a).

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

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

* *Threshold for one percent risk used to assess mitigation effectiveness.*

*** Impulse delivered over 20 percent of the estimated lung resonance period [see* (Navy 2017a)].

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).

Marine Mammal Criteria for Behavioral Response

Within the Navy's quantitative analysis, many behavioral reactions are predicted from exposure to sound that may exceed an animal's behavioral threshold momentarily. It is likely that some of the resulting estimated behavioral harassment takes would not constitute a significant disruption of normal behavior patterns. The Navy and NMFS have used the best available science to address the challenging differentiation between significant and non-significant behavioral reactions, but have erred on the side of caution where uncertainty exists (i.e., counting shorter duration behavioral reactions as a significant effect). This may result in some degree of overestimation of the number of significant behavioral disruptions. Therefore, this analysis includes the maximum number of potential behavioral disturbances and responses that are reasonably certain to occur. The following sections describe the behavioral response criteria and thresholds used in the analysis for each acoustic source.

Sonar – Marine Mammals

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

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

Moderate severity responses would be considered significant if they were sustained for a duration long enough that they cause variations in an animal's daily behavior outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. What constitutes a long-duration response is different for each situation and species, although it is likely dependent upon the magnitude of the response and species characteristics such as age, body size, feeding strategy, and behavioral state at the time of the exposure. In general, a response could be considered significant if it lasted for a few tens of minutes to a few hours, or enough time to significantly disrupt an animal’s daily routine. Moderate severity responses included the following:

- alter migration path;
- alter locomotion (speed, heading);
- alter dive profiles;
- stop/alter nursing;
- stop/alter breeding;
- stop/alter feeding/foraging;

- stop/alter sheltering/resting;
- stop/alter vocal behavior if tied to foraging or social cohesion; and
- avoidance of area near sound source

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have continued if the exposure had continued. Many of the behavioral responses estimated using the Navy's quantitative analysis are expected to be of moderate severity based on the behavioral response severity scale described in Southall et al. (2007). The costs associated with these observed behavioral reactions were not measured so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 4 and Figure 5). These divisions are driven by taxonomic classifications (e.g., odontocetes, mysticetes). The analysis for active sonar used cutoff distances beyond which recent research suggests the potential for significant behavioral responses (and therefore harassment under the ESA) is considered to be unlikely (Table 4). For animals within the cutoff distance, a behavioral response function based on a received SPL was used to predict the probability of a potential significant behavioral response. For training and testing events that contain multiple platforms or tactical sonar sources that exceed 215 dB re 1 μPa @ 1 m, this cutoff distance is substantially increased (i.e., doubled) from values derived from the literature. The use of multiple platforms and intense sound sources are factors that are expected to increase responsiveness in marine mammals overall. There are currently few behavioral observations under these circumstances. For this reason, and to be conservative in the analysis of potential effects, the Navy predicted significant behavioral responses at further ranges for the more intense activities.

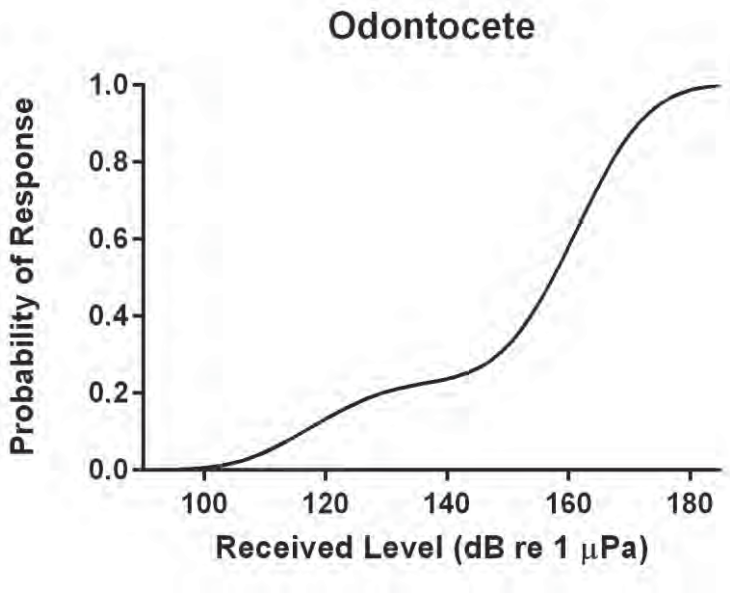


Figure 4. Behavioral response function for odontocetes (Navy 2017a).

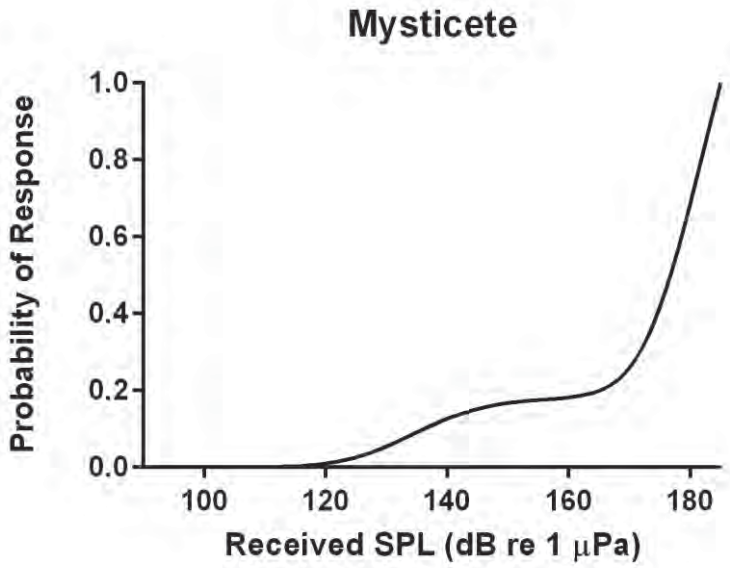


Figure 5. Behavioral response function for mysticetes (Navy 2017a).

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

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

[1] *High sources levels are defined as levels at or exceeding 215 dB 1 μPa at 1 meter; km = kilometer.*

Explosives Criteria – Marine Mammals

Phase III explosive criteria for behavioral thresholds for marine mammals is the hearing group's TTS threshold minus five dB (See Table 2 above for the TTS thresholds for explosives) for events that contain multiple impulses from explosives underwater.

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

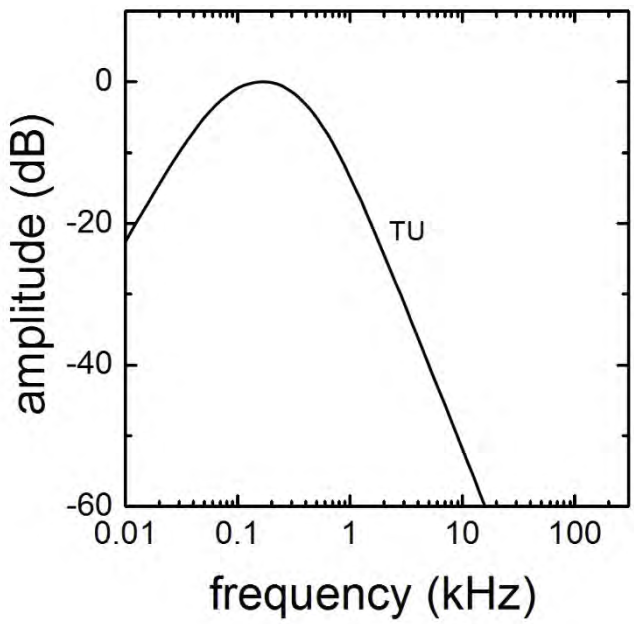
Functional Hearing Group	Sound Exposure Level (weighted)
Low-frequency cetaceans	163
Mid-frequency cetaceans	165

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

Sea Turtle Criteria for Hearing Impairment, Non-Auditory Injury, and Mortality

To develop hearing thresholds of received sound sources expected to produce TTS and PTS in sea turtles, the Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group. Measured or predicted auditory threshold data, as well as measured equal latency contours, were used to influence the weighting function shape for sea turtles. Weighting function parameters were adjusted to provide the best fit to the experimental data. The same methods were then applied to other species for which TTS data did not exist. However, because these data were insufficient to successfully model a composite audiogram via a fitted curve, as was done for marine mammals, median audiogram values were used in forming the sea turtle hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fish, an auditory weighting function was created to estimate the susceptibility of sea turtles to hearing loss or damage. This auditory weighting function for sea turtles is shown in Figure 6, and is described in detail in the technical

report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017a). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle (Navy 2017a).



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

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

Explosives Criteria – Sea Turtles

In order to estimate exposure of ESA-listed sea turtles to explosives, we relied on acoustic thresholds for impulsive sounds developed by the Navy for Phase III activities. For sea turtles, the Navy developed criteria to determine the potential onset of hearing loss, physical injury (non-auditory) and non-injurious behavioral response to detonation exposure using the weighting function and hearing group described above, as well as the impulsive sound threshold criteria recommended by the 2014 ANSI Guidelines (Popper et al. 2014). The same statistical methodology described in NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA 2018) was used to derive thresholds for sea turtles (see marine mammal section above for derivation of the auditory weighting function and sea turtle audiogram). The derivation of these injury criteria (and the species mass estimates) are described in the *"Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)"* technical report (Navy 2017a).

Based on the sea turtle composite audiogram and data on the onset of TTS in fish, an auditory weighting function was created to estimate the susceptibility of sea turtles to TTS. Data from fish

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

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

Hearing Group	Generalized Hearing Range	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Sea Turtles	30 Hz to 2 kHz	204 dB re 1 μPa²·s SEL_{cum} 232 dB re: 1 μPa SPL (0-pk)	189 dB re 1 μPa²·s SEL_{cum} 226 dB re: 1 μPa SPL (0-pk)

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

As with all other species groups, NMFS and the Navy apply dual metric criteria to assess the potential onset of physical injury and hearing impairment from explosives for sea turtles. These criteria include both the peak pressure and the SEL. Similar to other marine species, the sound pressure or blast wave produced from a detonation does not only affect hearing, but may also induce other physical injuries such as external damage to the carapace, and internally to organs and blood vessels. The criteria for non-auditory injury for sea turtles were provided in Table 3

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

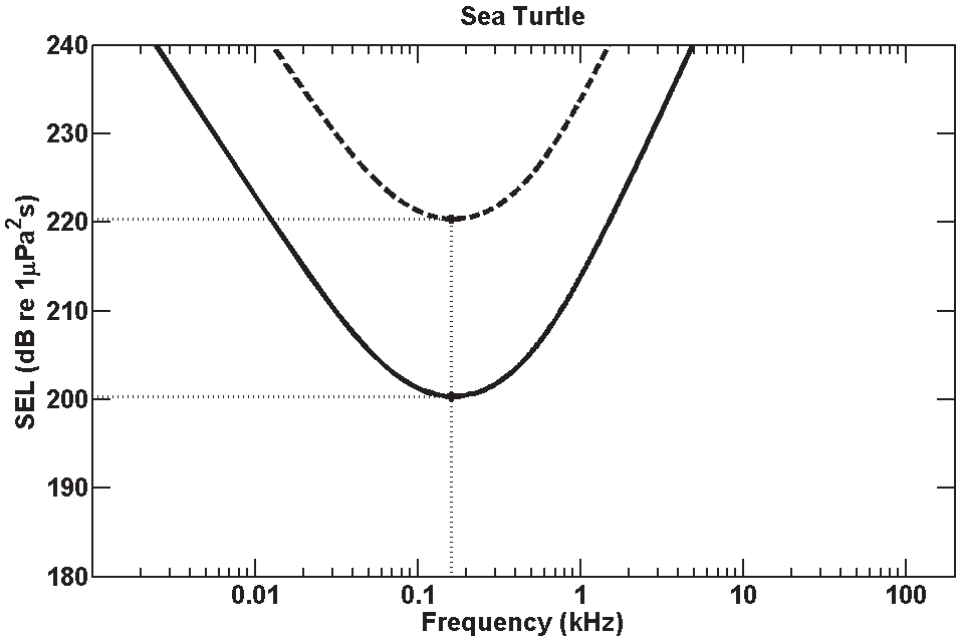
For hearing loss, the same thresholds applied for impulsive sound sources and sonar were used for explosives and provided above in Table 6. Similarly, for behavioral response assessment, NMFS requested that the Navy estimate the number of sea turtles that could be exposed to explosions at received levels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

Sonar Criteria – Sea Turtles

As mentioned above, no studies have been conducted specifically related to sea turtle hearing loss. The Navy evaluated sea turtle susceptibility to hearing loss (from sonar exposure) based upon what is known about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species such as marine mammals and fish.

In general, sea turtles appear to be capable of detecting low-frequency sonar (less than 1000 Hz), whereas frequencies for the peak sound pressure level (SPL) for mid-frequency sonar (2000 to 8000 hertz (Hz)) appear out of the range of sea turtle hearing sensitivity (Piniak 2012). However, it may be possible for sea turtles to detect high SPLs of mid-frequency sonar at increased sound pressure, but no studies have been conducted to date which expose sea turtles to these levels. Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on the methods proposed by Southall et al. (2007). Using this approach, dual metric thresholds were established for sea turtles for onset of PTS and TTS. This approach allows for the development of sea turtle exposure functions, shown below in Figure 7. These mathematical functions relate the SELs for onset of PTS or TTS to the frequency of the sonar sound. A full description of how the Navy derived these functions is provided in the technical

report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017a). Based upon this approach, sea turtle onset of TTS would be expected to occur if received sound levels exceed 200 dB, SEL_{cum} (re: 1 μPa^2-s) and PTS would occur for sounds that exceed 220 dB SEL_{cum} (re: 1 μPa^2-s) at an exposure frequency of 200Hz.



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

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

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

likely be higher than the risk of responding to sonar; so it is likely that potential sea turtle behavioral responses to sonar exposures are a sub-set of sea turtles exposed to received levels of 175 dB rms (re: 1 μPa) or greater.

2.2.3 Species Density Estimates

A quantitative effects analysis requires information on the abundance and density of ESA-listed species in the potentially impacted area. To characterize marine species densities in the MITT action area, the Navy compiled data from multiple sources and developed a protocol to select the best available density estimates based on species, area, and time (i.e., season). When multiple data sources were available, the Navy ranked density estimates based on a hierarchal approach to ensure that the most accurate estimates were selected. The highest tier included peer-reviewed published studies of density estimates from spatial models, since these provide spatially explicit density estimates with relatively low uncertainty. Other preferred sources included peer-reviewed published studies of density estimates derived from systematic line-transect survey data, the method typically used for NMFS marine mammal stock assessment reports. In the absence of survey data, information on species occurrence and known or inferred habitat associations have been used to predict densities using model-based approaches including Relative Environmental Suitability models. Because these estimates inherently include a high degree of uncertainty, they were considered the least preferred data source. In cases where a preferred data source was not available, density estimates were selected based on expert opinion from scientists. The resulting Geographic Information System database includes seasonal density values for every marine mammal and sea turtle species present within the action area, and density data are provided as a geographic grid of typically 10 km x 10 km. This database is described in the technical report titled *U.S. Navy Marine Species Density Database Phase III for the Mariana Islands Training and Testing Study Area (Navy 2018e)*, hereafter referred to as the Density Technical Report. These data were used as an input into the NAEMO. As noted above, the Navy did not estimate the number of instance of exposure to ESA-listed fish species due to a lack of density data for these species in the action area. Marine mammal and sea turtle density estimates that were used in NAEMO modeling for acoustic effects and our risk analyses on the effects of various stressors from Navy training and testing activities are summarized below. Estimates of abundance or density for corals, scalloped hammerhead sharks, oceanic whitetip sharks, and giant manta rays in the MITT action area were not available.

Marine Mammal Density Estimates

Marine mammal density estimates that were used in NAEMO modeling for acoustic effects and our risk analyses on the effects of various stressors from Navy training and testing activities are summarized in Table 7. This table also includes the density estimates used for MITT Phase II analyses and an explanation of any changes based on new information. Figure 8 shows the spatially explicit density estimates that were used for sperm whales.

Table 7. Density estimates for ESA-listed marine mammals in the action area.

Species	Density Estimate and Source		Change from MITT Phase II	Rationale for update (if applicable)
	Density Estimates and CV (if available)	Source(s)		
Blue whale	All areas: 0.00005 (CV = 1.09) Density layer for summer season = 0.	Bradford et al. (2017)	Phase II estimate: 0.00001 (CV = 1.00)	Per guidance from PIFSC/SWFSC, in the absence of action area specific data, Hawaiian Islands Exclusive Economic Zone (EEZ) line-transect estimates represent the best available estimates. There was not a line-transect density estimate for blue whale available for Phase II but there was for Phase III so the estimate was updated accordingly.
Fin whale	All areas: 0.00006 (CV = 1.05) Density layer for summer season = 0.	Bradford et al. (2017)	Phase II estimate: 0.00001 (CV = 1.00)	Per guidance from PIFSC/SWFSC, in the absence of action area specific data, Hawaiian Islands EEZ line-transect estimates represent the best available estimates. There was not a line-transect density estimate for fin whale available for Phase II but there was for Phase III so the estimate was updated accordingly
Sei whale	0.00029 (CV = 0.49) Density layer for summer season = 0. Transit corridor: 0.000130	Fulling et al. (2011)	No change	
Humpback whale	All areas: 0.00089 (for NAEMO) Density layer for summer season = 0. Chalan Kanoa and Marpi Reef Geographic Mitigation Areas: Used average abundance estimate of 61 whales (range 41-91)	LGL (2008) Hill et al. (2020a)	No change	Based on new information collected by the PIFSC during 2015-2019 surveys.
Sperm whale	Spatially-explicit for MISTCS survey area (see Figure 8). Other areas within MITT: 0.00123 (CV = 0.604) Transit Corridor: 0.00222	Yack et al. (2016)(spatially-explicit for MISTCS survey region) Fulling et al. (2011) (elsewhere)	All areas: 0.00123 (CV = 0.60)	Yack et al. (2016) developed a habitat model for sperm whale for the MISTCS survey area subsequent to Phase II that provided spatially-explicit density estimates for this region. The Fulling et al. line-transect estimate used for Phase II was applied to the remainder of the MITT action area for Phase III.

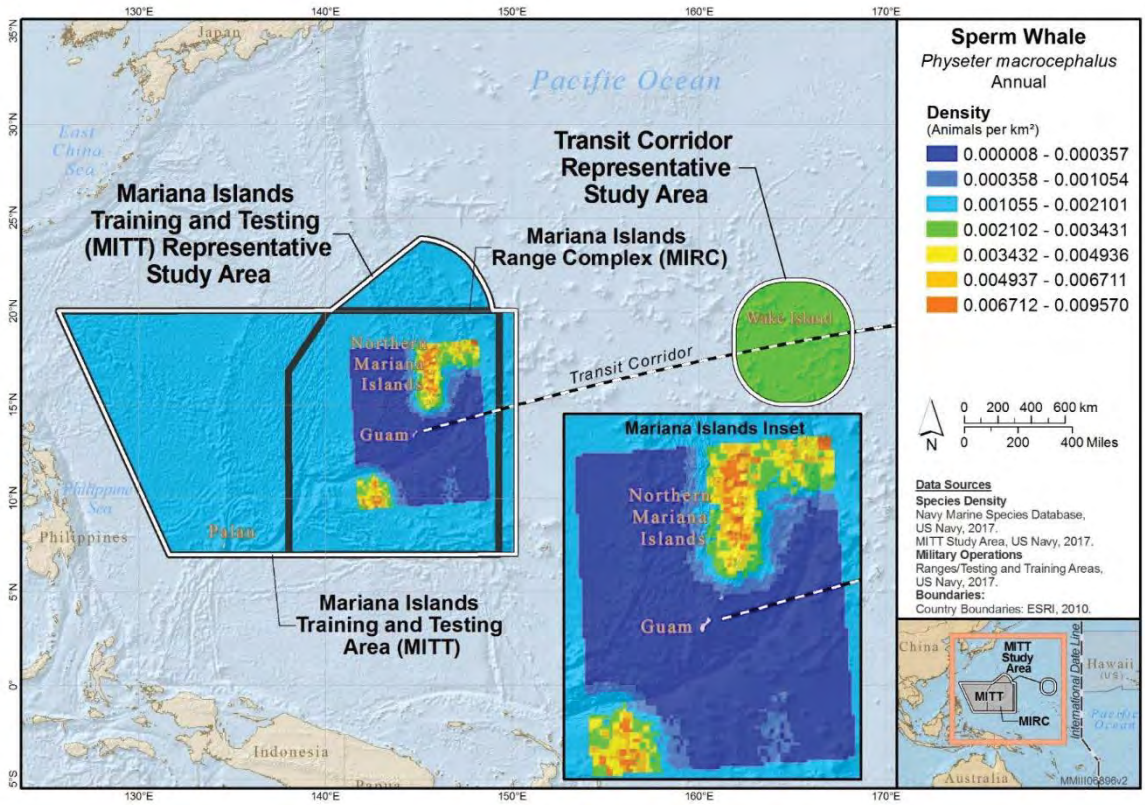


Figure 8. Spatially explicit density estimates used for sperm whale quantitative analyses (Navy 2019e).

Sea Turtle Density Estimates

Green sea turtle (Table 8, Figure 9, and Figure 10) and hawksbill sea turtle (Table 9, Figure 11, and Figure 12) density estimates that were used in NAEMO modeling for acoustic effects and our risk analyses on the effects of various stressors from Navy training and testing activities are summarized below. For leatherbacks, the Navy estimated that 6.5 percent of the population from regional nesting locations would transit through the action area. The estimate is based on the tracks of satellite-tagged leatherbacks leaving nesting sites in the western Pacific (Benson et al. 2011). An abundance estimate of 900 females was derived from counts at nesting sites reported by Hitipeuw et al. (2007) and supplemented with an additional 30 percent to account for males transiting through the action area (Benson et al. 2011; Curtis et al. 2015). The abundance and density were calculated as:

- *Abundance = 900 (nesting females) + (900 x 0.30 males) = 1,170 sea turtles*
- *Density = (1,170 sea turtles x 0.065) / 3,456,818 km^2 = 0.000022 sea turtles/km^2*

The Navy's estimate of 0.000022 leatherback sea turtles per km^2 was applied to all portions of the MITT action area during all times of year (Navy 2018e). Given the lack of loggerhead data in

the action area, the Navy used the density derived for leatherback sea turtles (0.000022 animals per square kilometer (km^2)) as a proxy for loggerheads in the action area (Navy 2019e).

Table 8. Summary of Navy Density Estimates for Green Sea Turtles in the action area (Navy 2019e).

Location	Density (Animals/km^2)			
	Spring	Summer	Fall	Winter
Apra North	0	0	0	0
Apra South	8.7483	12.5341	12.5341	8.7483
Apra Gab	25.9168	24.5057	24.5057	25.9168
Apra Glass Breakwater	0	8.4255	8.4255	0
Apra Inner	0	0	0	0
Apra Kilo	9.7966	31.8549	31.8549	9.7966
Apra Orote	4.3389	5.2032	5.2032	4.3389
Apra Sumay East	2.5962	0	0	2.5962
Guam Nearshore Zone 1	0.17	0.17	0.17	0.17
Guam Nearshore Zone 2/	0.153	0.153	0.153	0.153
Guam Nearshore Zone 3	0.0255	0.0255	0.0255	0.0255
Guam Nearshore Zone 4	0.0595	0.0595	0.0595	0.0595
Guam Nearshore Zone 5	0.068	0.068	0.068	0.068
Guam Nearshore Zone 6	0.1445	0.1445	0.1445	0.1445
Guam Nearshore Zone 7	0.1955	0.1955	0.1955	0.1955
Guam Nearshore Zone 8	1.768	1.768	1.768	1.768
Guam Nearshore Zone 9	0.2805	0.2805	0.2805	0.2805
Guam Nearshore Zone 10	0.204	0.204	0.204	0.204
Guam Nearshore Zone 11	0.102	0.102	0.102	0.102
Guam Nearshore Zone 12	0.3145	0.3145	0.3145	0.3145
Tinian Nearshore	92.4921	92.4921	92.4921	92.4921
Pagan Nearshore	39.3113	39.3113	39.3113	39.3113
Rota Nearshore	92.4921	92.4921	92.4921	92.4921
Saipan Nearshore	0.1615	0.1615	0.1615	0.1615
All Other Nearshore Areas	65.9017	65.9017	65.9017	65.9017
MITT (Offshore and Transit Corridor)	0.00039	0.00039	0.00039	0.00039

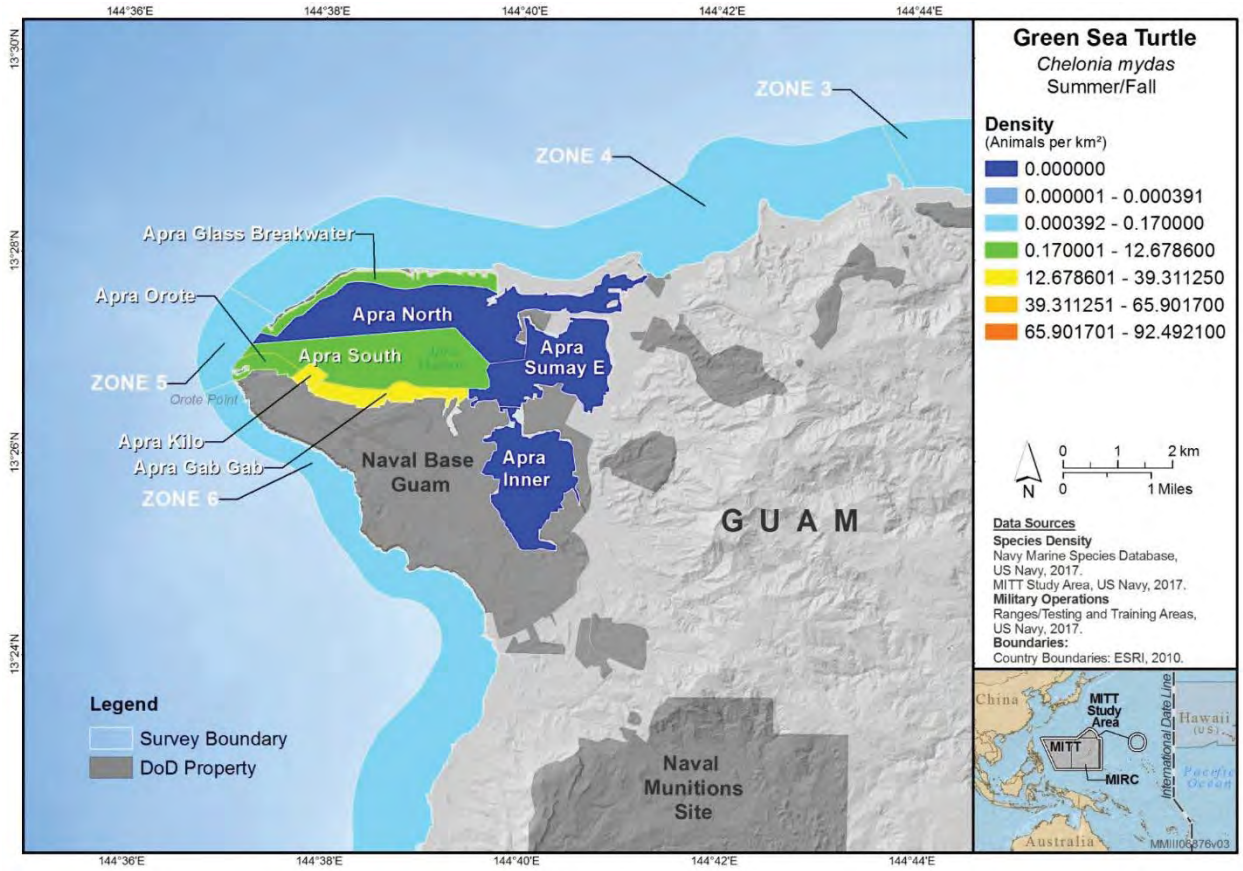


Figure 9. Summer/fall distribution of green sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e).

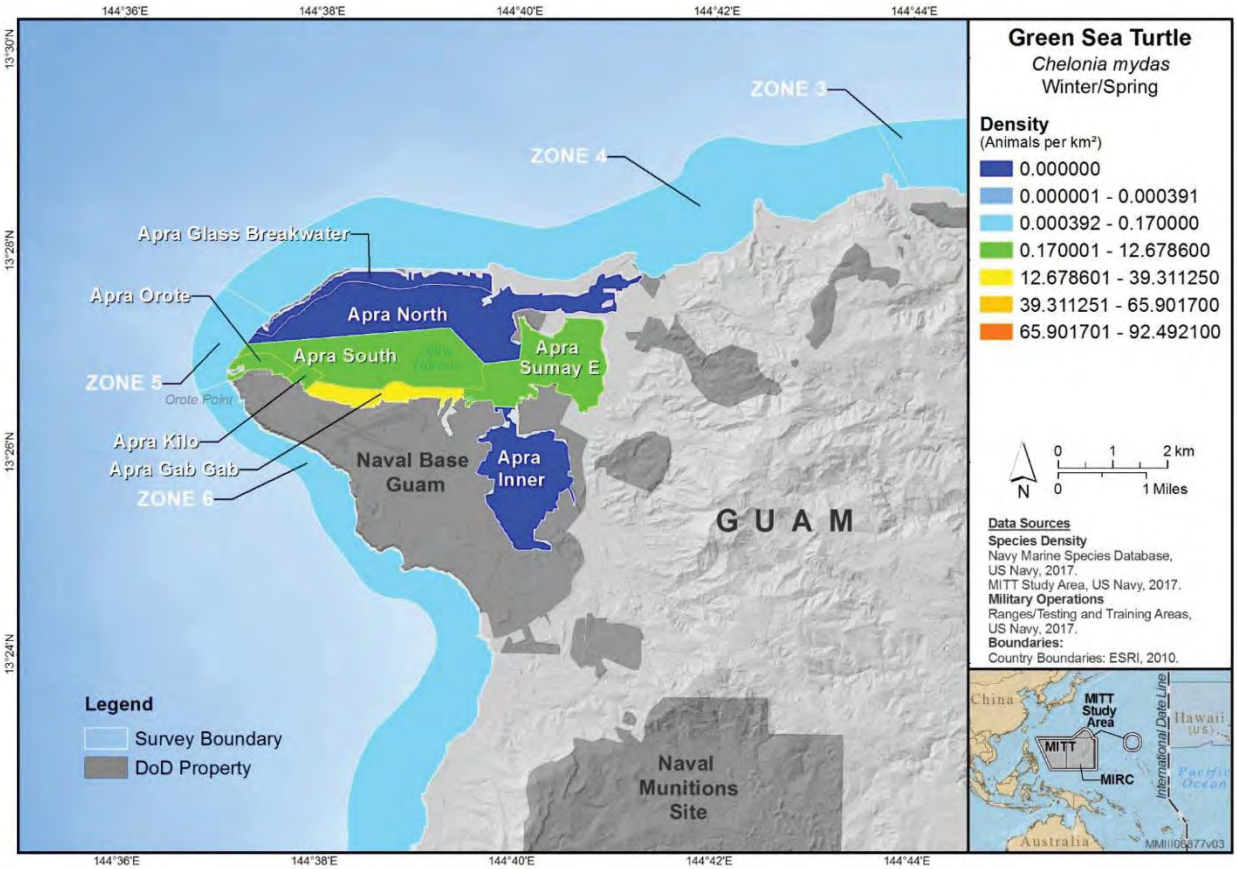


Figure 10. Winter/spring distribution of green sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e).

Table 9. Summary of Navy Density Estimates for Hawksbill Sea Turtles in the action area (Navy 2019e).

Location	Density (Animals/km²)			
	Spring	Summer	Fall	Winter
Apra North	0	0	0	0
Apra South	0.1009	0.1445	0.1445	0.1009
Apra Gab	0.2989	0.2826	0.2826	0.2989
Apra Glass Breakwater	0	0.09716	0.09716	0
Apra Inner	0	0	0	0
Apra Kilo	0.1130	0.3673	0.3673	0.1130
Apra Orote	0.0500	0.0600	0.0600	0.0500
Apra Sumay East	0.0299	0	0	0.0299
Guam Nearshore Zone 1	0.03	0.03	0.03	0.03
Guam Nearshore Zone 2	0.027	0.027	0.027	0.027
Guam Nearshore Zone 3	0.0045	0.0045	0.0045	0.0045

Guam Nearshore Zone 4	0.0105	0.0105	0.0105	0.0105
Guam Nearshore Zone 5	0.012	0.012	0.012	0.012
Guam Nearshore Zone 6	0.0255	0.0255	0.0255	0.0255
Guam Nearshore Zone 7	0.0345	0.0345	0.0345	0.0345
Guam Nearshore Zone 8	0.312	0.312	0.312	0.312
Guam Nearshore Zone 9	0.0495	0.0495	0.0495	0.0495
Guam Nearshore Zone 10	0.036	0.036	0.036	0.036
Guam Nearshore Zone 11	0.018	0.018	0.018	0.018
Guam Nearshore Zone 12	0.0555	0.0555	0.0555	0.0555
Tinian Nearshore	5.9038	5.9038	5.9038	5.9038
Pagan Nearshore	20.25125	20.2513	20.2513	20.25125
Rota Nearshore	5.9038	5.9038	5.9038	5.9038
Saipan Nearshore	0.0285	0.0285	0.0285	0.0285
Farallon de Medinilla	1.0734	1.0734	1.0734	1.0734
All Other Nearshore Areas	13.0775	13.0775	13.0775	13.0775
MITT (Offshore and Transit Corridor)	0.000024	0.000024	0.000024	0.000024

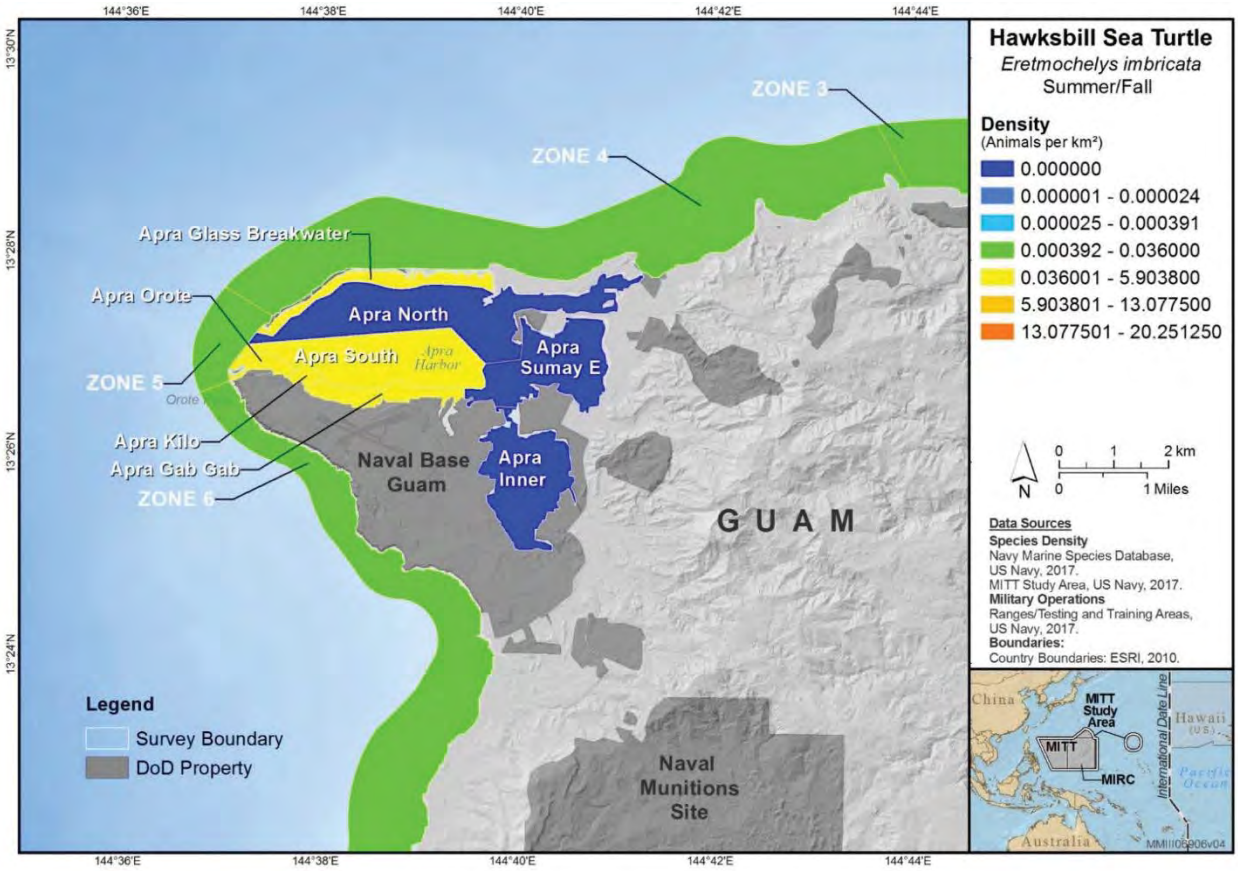


Figure 11. Summer/fall distribution of hawksbill sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e).

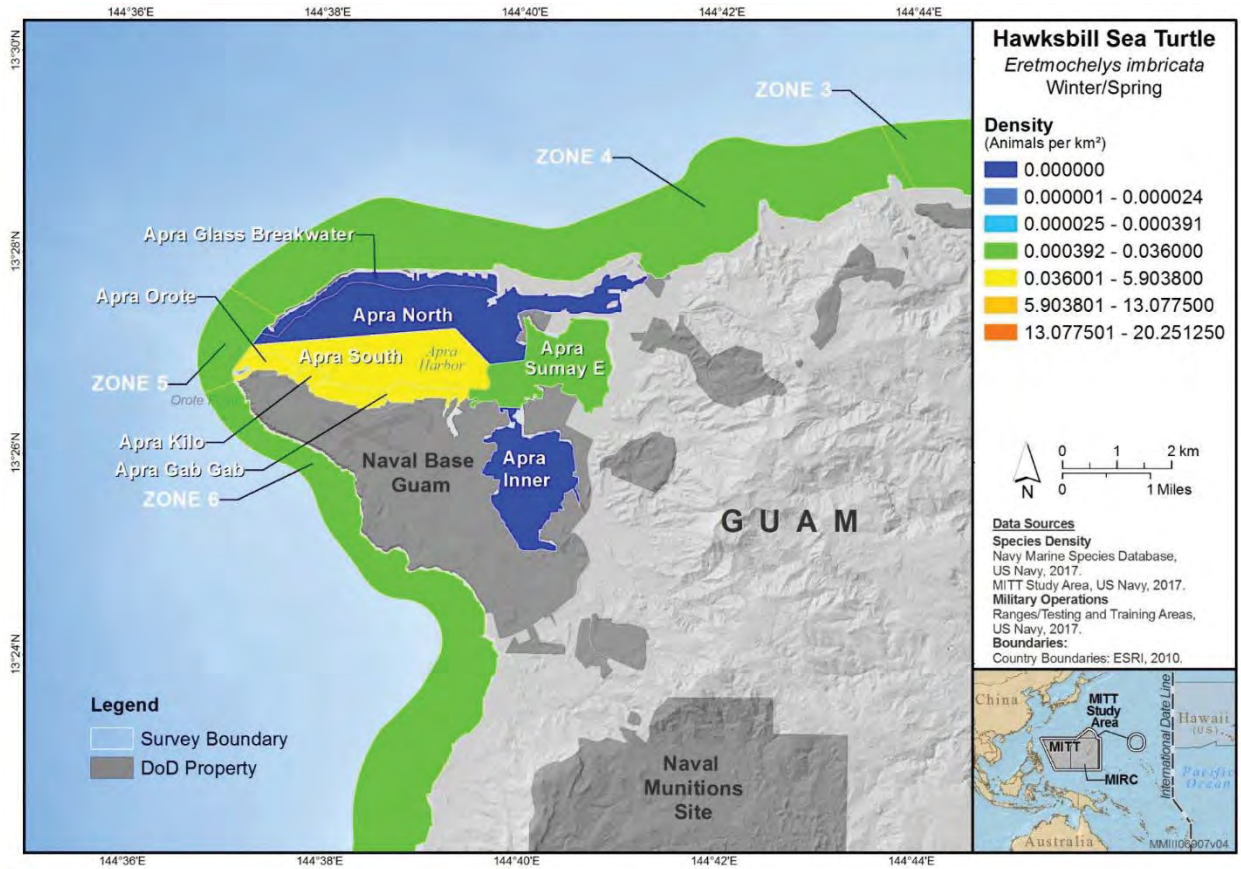


Figure 12. Winter/spring distribution of hawksbill sea turtles in Apra Harbor and nearshore portions of Guam (Navy 2019e).

2.2.4 Criteria and Thresholds to Predict Impacts to Fish

ESA-listed fish occurring in the action area have the potential to be exposed to sonar and other transducers during Navy activities. Fish without a swim bladder, which includes all ESA-listed fish in the action area, are likely only capable of detecting sounds from low-frequency sources. The sound characteristics (e.g., non-impulsive) of sonar are considered to pose less risk to fish because they have lower peak pressures and slow rise times. Direct injury from sonar and other transducers is considered highly unlikely because injury from sound levels produced from sonar has not been documented in fish (Halvorsen et al. 2012; Kane et al. 2010; Popper et al. 2007; Popper et al. 2014; Popper et al. 2013).

PTS has not been documented in any of the studies researching fish hearing and potential impairment from various sound sources. This is attributed to the ability for regeneration of inner ear hair cells in fish, which differs from marine mammals and sea turtles. While TTS in fish is considered recoverable, 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 has also applied an rms threshold for some acoustics sources to assess whether behavioral responses may be elicited during some sound exposures. In order to evaluate the effects of sonar use during Navy activities, NMFS and the Navy use the criteria for sonar and fish based upon the recommendations provided in the 2014 ANSI Guidelines.

NMFS does not currently have "formal" criteria established for explosives thresholds and effects on fish, and in most cases bases interim thresholds upon the lowest level of sound where onset of effects may occur. In general, this lowest level (SEL_{cum}) correlates with TTS and therefore typically establishes the starting point where a spectrum of effects may occur for fish ranging from TTS, to minor, recoverable injury, to lethal injury and mortality. The Navy used a similar approach, and based the mortality threshold used for analyses upon the lowest pressure levels supported in the scientific literature (Hubbs and Rechnitzer 1952). This is consistent with other NMFS explosives analyses for fish as well as with the recommendation described more recently with the 2014 ANSI Guidelines (Popper et al. 2014). The 2014 ANSI Guidelines provide a conservative peak value for mortality, which allows for calculation of a maximum lethal impact range for fish exposed to underwater detonations.

The criteria provided in the 2014 ANSI Guidelines divides fish according to presence or absence of a swim bladder. None of the ESA-listed elasmobranchs occurring in the action area have a swim bladder. The Navy used the following criteria to model range to effects for fish without a swim bladder: onset of physical injury would be expected if the peak SPL exceeds 220 dB re 1 μPa; onset of mortality would be expected if the peak SPL reaches 229 dB re 1 μPa (Navy 2019e). The 229 dB peak SPL for mortality, as recommended by Popper et al. (2014), was derived from Hubbs and Rechnitzer (1952). The 220 dB peak SPL was based on a compilation of data from a variety of studies on the effects of explosives on fishes with swimbladders (Gaspin 1975; Gaspin et al. 1976; Hubbs and Rechnitzer 1952; Settle et al. 2002; Yelverton et al. 1975). Studies have shown that fish without swim bladders are much less susceptible to injury from explosions than fish with swim bladders (Popper et al. 2014; Yelverton et al. 1975). Therefore the Navy's proposed criteria (220/229 dB peak SPL criteria for injury and mortality) is likely conservative for the sharks and rays considered in this opinion.

TTS has not been documented in fish without a swim bladder from exposure to other impulsive sources (pile driving and air guns) (Navy 2019e). Although it is possible that fish without a swim bladder could receive TTS from exposure to explosives, these species are typically less susceptible to hearing impairment than species with a swim bladder. If TTS occurs in fish without a swim bladder, it would likely occur within the range of injury; therefore, no thresholds for TTS are proposed (Navy 2019e).

3 DESCRIPTION OF THE PROPOSED ACTION

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

This consultation addressed three interdependent actions conducted by the Navy and NMFS's Permits Division: (1) the Navy's military training and testing activities (i.e., readiness activities) conducted in the MITT Study Area; (2) NMFS's Permits Division's promulgation of regulations pursuant to the MMPA governing the Navy's "take" of marine mammals incidental to the Navy's military readiness activities from August 2020 through August 2027; and (3) NMFS's Permits Division's issuance of an LOA pursuant to the regulations that authorize the U.S. Navy to "take" marine mammals incidental to military readiness activities in the MITT Study Area through August 2027.

The Navy proposes to conduct military readiness training and testing ("testing" includes research, development, testing, and evaluation) activities in the MITT action area (see Section 4 for description of the action area). These military readiness activities include the use of active sonar and explosives within established operating and warning areas and are representative of training and testing the Navy has been conducting in the MITT action area for decades.

The Permits Division proposes to promulgate regulations pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to MITT activities from August 2020 to August 2027. The regulations propose to authorize the issuance of a LOA that will allow the Navy to "take" marine mammals incidental to their training and testing activities. The Permits Division's proposed regulations are available at the following website: *https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities.* This consultation considers the MMPA regulations for the Navy to "take" marine mammals incidental to MITT activities, as modified during ESA consultation. The final MMPA regulations, upon publication, will also be available at the website shown above. It should be noted that this biological opinion was completed prior to the publication of the final MMPA regulations in the Federal Register. We anticipate that, upon final publication, the MMPA regulations will reflect the mitigation and monitoring measures proposed by the Navy and/or agreed to during ESA consultation (a description of the mitigation measures is in Section 3.6.2 of this opinion). We also anticipate that the levels of take of ESA-listed marine mammals authorized under the final MMPA regulations and LOA will be consistent with those analyzed in this opinion and exempted in the ITS. Upon publication of final regulations, we will review the MMPA regulations to ensure these conditions are met and the amount and extent of exempted take is consistent with this opinion. If administrative changes are needed following publication of the MMPA regulations, we will update the biological opinion to reflect

these changes. If more substantive changes are needed, the reinitiation triggers described in Section 15 may apply.

NMFS recognizes that while Navy training and testing requirements change over time in response to global or geopolitical events and other factors, the general types 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 Navy during the period of NMFS' proposed incidental take authorization pursuant to the MMPA would continue into the reasonably foreseeable future at levels similar to those described in this opinion. While our effects analysis considers the foreseeable future, because of the interrelationship between the Navy action and the Permits Division's action, additional ESA section 7 consultation would be needed to cover the period after the seven-year MMPA authorization expires.

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

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

3.1 Mariana Islands Training Activities

The following sections describe the training activities occurring in the MITT study area.

3.1.1 Anti-Air Warfare

The mission of anti-air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Anti-air warfare also includes providing U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces. Table 10 provides summaries of training activities in support of anti-air warfare.

Aircraft conduct anti-air warfare through radar search, detection, identification, and engagement of airborne threats-generally by firing anti-air missiles or cannon fire. Surface ships conduct anti-air warfare through an array of modern anti-air warfare 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.

Table 10. Anti-Air warfare training exercises.

Activity Name	Activity Description
Anti-Air Warfare	
Air Combat Maneuver	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Defense Exercise (ADEX)	Aircrew and ship crews conduct defensive measures against threat aircraft or simulated missiles.
Air Intercept Control (AIC)	Aircrew and air controllers conduct aircraft intercepts of other aircraft.
Gunnery Exercise (GUNEX)(Air-to-Air)- Medium caliber	Fixed-wing aircrews fire medium-caliber guns at air targets.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A]) – Large-caliber	Surface ship crews fire large- caliber guns at air targets.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A]) – Medium-caliber	Surface ship crews fire medium- caliber guns at air targets.
Missile Exercise (Air-to- Air)	Fixed-wing aircrews fire air-to- air missiles at air targets.
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	Surface ship crews fire surface- to-air missiles at air targets.

3.1.2 Amphibious Warfare

The mission of amphibious warfare is to project military power from the sea to the shore through the use of naval firepower and Marine Corps landing forces. It is used to attack a threat located on land by a military force embarked on ships. Amphibious warfare operations include small unit reconnaissance or raid missions to large-scale amphibious operations involving multiple ships and aircraft combined into a strike group. Table 11 provides summaries of training activities in support of amphibious warfare.

Amphibious warfare training ranges from individual, crew, and small unit events to large task-force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Small-unit training operations include shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, and air strike and close air support training.

Table 11. Typical amphibious warfare training exercises.

Activity Name	Activity Description
Amphibious Warfare	
Naval Surface Fire Support Exercise (FIREX) Land-Based Target [Land]	Surface ship crews fire large- caliber guns at land-based targets in support of forces ashore.
Amphibious Rehearsal, No Landing	Amphibious shipping, landing craft, and aviation elements rehearse amphibious landings without conducting an actual landing on shore.
Amphibious Assault	Large unit forces move ashore from amphibious ships at sea for the immediate execution of inland objectives.
Amphibious Raid	Small unit forces move from amphibious ships at sea for a specific short-term mission. These are quick operations with as few personnel as possible.
Noncombatant Evacuation Operation	Military units evacuate noncombatants from hostile or unsafe areas
Humanitarian Assistance / Disaster Relief Operations	Military units provide humanitarian assistance in times of disaster.
Unmanned Aerial Vehicle – Intelligence, Surveillance, and Reconnaissance	Military units employ unmanned aerial vehicles to launch, operate, and gather intelligence for specified amphibious missions.
Special Purpose Marine Air Ground Task Force Exercise	Similar to Marine Air Ground Task Force (Amphibious) – Battalion, but task organized to conduct a specific mission (e.g., Humanitarian Assistance, Disaster Relief, Noncombatant Evacuation Operations).

Amphibious Warfare activities account for 60.7 percent of total surface ship days (Navy 2019a). Amphibious Major Training Events or MTEs [Joint Expeditionary Exercise, Marine Air Ground Task Force Exercise (Amphibious) – Battalion] and other amphibious warfare activities involve amphibious assault ships maneuvering offshore then approaching designated beach landing areas to offload marines in landing craft, amphibious assault vehicles, or helicopters. Typical landing locations depending on activity type include Guam, Rota, Saipan, and Tinian (Tinian Military Lease Area). For large surface vessels during amphibious warfare activities, the objective is to not approach too close to shore, which would put a ship at risk from shore-based defenses. Typically, amphibious transport ships deploy landing craft, amphibious assault vehicles, or helicopters from several miles offshore. Given the steep nearshore bathymetry in the Mariana Islands less than three nautical miles (NM) from shore, these ships are still in significantly deep water while deploying units (water depths greater than 200 meters).

3.1.3 Strike Warfare

The mission of strike warfare is to conduct offensive attacks on land-based targets, such as refineries, power plants, bridges, major roadways, and ground forces to reduce the enemy's ability to wage war. Strike warfare employs weapons by manned and unmanned air, surface, submarine, and naval special warfare assets in support of extending dominance over enemy

territory (power projection). Table 12 provides summaries of training activities in support of strike warfare.

Strike warfare includes training of fixed wing attack aircraft pilots and aircrews in the delivery of precision-guided munitions, non-guided munitions, rockets, and other ordnance, including the high-speed anti-radiation missile, against land-based targets in all conditions. Not all strike mission training events involve dropping ordnance and instead the event is simulated with video footage obtained by onboard sensors.

Table 12. Strike warfare training exercises.

Activity Name	Activity Description
Strike Warfare	
Bombing Exercise (BOMBEX) (Air-to-Ground [A-G])	Fixed-wing aircraft drop bombs against a land target.
Gunnery Exercise (GUNEX) (Air-to-Ground)	Helicopter crews fire guns at stationary land targets; fixed- wing aircraft also strafe land targets.
Missile Exercise (MISSILEX) (Air-to-Ground)	Missiles or rockets are launched against a land target.

3.1.4 Anti-Surface Warfare

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched cruise missiles or other precision guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles. Table 13 provides summaries of training activities in support of anti-surface warfare.

Anti-surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or torpedo launch events.

Table 13. Anti-surface warfare training exercises.

Activity Name	Activity Description
Anti-Surface Warfare	
Gunnery Exercise (GUNEX) (Air-to-Surface) – Small- caliber	Fixed-wing, helicopter aircrews fire small-caliber guns at surface targets.
Gunnery Exercise (GUNEX) (Air-to-Surface) – Medium-caliber	Fixed-wing, helicopter aircrews fire medium-caliber guns at surface targets.
Missile Exercise (Air-to- Surface) – Rocket (MISSILEX [A-S] – Rocket)	Helicopter aircrews fire precision-guided, unguided rockets at surface targets
Missile Exercise (Air-to- Surface) (MISSILEX [A-S])	Fixed-wing, helicopter aircrews fire air-to-surface missiles at surface targets

Activity Name	Activity Description
Laser Targeting (at sea)	Fixed-wing and helicopter aircrews and shipboard personnel illuminate enemy targets with lasers.
Bombing Exercise (BOMBEX) (Air-to-Surface)	Fixed-wing aircrews deliver bombs against stationary surface targets
Missile Exercise (Surface- to-Surface) (MISSILEX [S- S])	Surface ship crews defend against surface threats (ships or small boats) and engage with missiles
Gunnery Exercise (GUNEX) (Surface-to- Surface) Ship – Large- caliber	Surface ship crews fire large- caliber guns at surface targets
Gunnery Exercise (GUNEX) (Surface-to- Surface) Ship – Small- and Medium-caliber	Surface ship crews fire medium and small-caliber guns at surface targets
Sinking Exercise (Representative ordnance. Actual ordnance used will vary)	Aircraft, ship, submarine crews deliberately sink seaborne target, usually decommissioned ship made environmentally safe for sinking according to U.S. Environmental Protection Agency standards, with variety of ordnance
Gunnery Exercise (GUNEX) (Surface-to- Surface) Boat – Medium- caliber	Small boat crews fire medium- caliber guns at surface targets
Gunnery Exercise (GUNEX) (Surface-to- Surface) Boat – Small- caliber	Small boat crews fire small- caliber guns at surface targets
Maritime Security Operations	Helicopter, surface ship, small boat crews conduct suite of maritime security operations at sea, to include visit, board, search and seizure, maritime interdiction operations, force protection, anti-piracy operations

3.1.5 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats. Table 14 provides summaries of training activities in support of anti-submarine warfare.

Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, and distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, fixed wing aircraft, and helicopters. This training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes or simulated weapons.

Table 14. Anti-submarine warfare training exercises.

Activity Name	Activity Description
Anti-Submarine Warfare	
Tracking Exercise – Helicopter (TRACKEX – Helo)	Helicopter crews search for, detect, track submarines
Torpedo Exercise – Helicopter (TORPEX – Helo)	Helicopter crews search for, detect, track submarines. Recoverable air launched non- explosive torpedoes employed against submarine targets
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – Maritime Patrol Aircraft)	Maritime patrol aircraft crews search for, detect, track submarines
Torpedo Exercise – Maritime Patrol Aircraft (TORPEX – Maritime Patrol Aircraft)	Maritime patrol aircraft crews search for, detect, track submarines. Recoverable air launched non-explosive torpedoes employed against submarine targets
Tracking Exercise – Surface (TRACKEX – Surface)	Surface ship crews search for, detect, track submarines
Torpedo Exercise – Surface (TORPEX – Surface)	Surface ship crews search for, detect, track submarines. Non- explosive exercise torpedoes used
Torpedo Exercise – Submarine (TORPEX – Sub)	Submarine crews search for, detect, track submarines. Recoverable non-explosive exercise torpedoes used
Tracking Exercise – Submarine (TRACKEX – Sub)	Submarine crews search for, detect, track submarines
Small Joint Coordinated ASW exercise- (e.g., Multi Sail/GUAMEX/ SWATT)	Multiple ships, aircraft, submarines integrating use of sensors to search, detect, track submarines

3.1.6 Electronic Warfare

The mission of electronic warfare is to degrade the enemy's ability to use their electronic systems, such as communication systems and radar, in order to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to recognize an emerging threat and counter an enemy’s attempt to degrade the electronic capabilities of the Navy.

Table 15 provides summaries of training activities in support of electronic warfare.

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

Table 15. Electronic warfare training exercises.

Activity Name	Activity Description
Electronic Warfare	
Electronic Warfare Operations (EW OPS)	Aircraft and ship crews control portions of the electromagnetic spectrum to degrade or deny the enemy's ability to take defensive actions.
Counter Targeting – Flare Exercise (FLAREX) – Aircraft	Fixed-wing and helicopter aircrews deploy flares to disrupt threat infrared missile guidance systems.
Counter Targeting Chaff Exercise (CHAFFEX) – Ship	Surface ship crews deploy chaff to disrupt threat radars.
Counter Targeting Chaff Exercise (CHAFFEX) – Aircraft	Fixed-wing and helicopter aircrews deploy chaff to disrupt threat radars.

3.1.7 Mine Warfare

The mission of mine warfare is to detect, and avoid or neutralize mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control of, or deny the enemy access to sea space. Naval mines can be laid by ships (including purpose-built minelayers), submarines, or aircraft. The Navy divides mine warfare systems into two categories: mine detection and mine neutralization.

Mine detection systems are used to locate, classify, and map suspected mines, on the surface, in the water column, or on the sea floor. The Navy analyzed the following mine detection systems for potential impacts to marine mammals:

- Towed or hull-mounted mine detection systems. These detection systems use acoustic and laser or video sensors to locate and classify suspect mines. Fixed and rotary wing platforms, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.
- Unmanned/remotely operated vehicles. These vehicles use acoustic and video or lasers to locate and classify mines and provide unique capabilities in nearshore littoral areas, surf zones, ports, and channels.

Mine neutralization systems disrupt, disable, or detonate mines to clear ports and shipping lanes, as well as littoral, surf, and beach areas in support of naval amphibious operations. The Navy analyzed the following mine neutralization systems for potential impacts to ESA-listed species:

- Towed influence mine sweep systems. These systems use towed equipment that mimic a particular ship's magnetic and acoustic signature triggering the mine and causing it to explode.
- Unmanned/remotely operated mine neutralization systems. Surface ships and helicopters operate these systems, which place explosive charges near or directly against mines to destroy the mine.

- Airborne projectile-based mine clearance systems. These systems neutralize mines by firing a small or medium-caliber non-explosive, supercavitating projectile from a hovering helicopter.
- Diver emplaced explosive charges. Operating from small craft, divers put explosive charges near or on mines to destroy the mine or disrupt its ability to function.

Table 16 provides summaries of training activities in support of mine warfare. Mine warfare neutralization (destruction) training includes exercises in which ships, aircraft, submarines, or underwater vehicles search for mines. Personnel train to destroy or disable mines by attaching and detonating underwater explosives to the mine. Other neutralization techniques involve impacting the mine with a bullet-like projectile or intentionally triggering the mine to detonate.

Table 16. Mine warfare exercises.

Activity Name	Activity Description
Mine Warfare	
Civilian Port Defense	Maritime security personnel train to protect civilian ports and harbors against enemy efforts to interfere with access to those ports.
Mine Laying	Fixed-wing aircraft drop non- explosive mine shapes.
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Personnel disable threat mines using explosive charges.
Limpet Mine Neutralization System	Navy Explosive Ordnance Disposal divers place a small charge on a simulated underwater mine.
Airborne Mine Countermeasure – Towed Mine Detection	Helicopter aircrews detect mines using towed or laser mine detection systems.
Mine Countermeasure Exercise – Towed Sonar (AQS-20, LCS)	Surface ship crews detect, avoid mines while navigating restricted areas or channels using towed active sonar systems
Mine Countermeasure Exercise – Surface Ship Sonar (SQQ-32, MCM)	Ship crews detect, locate, identify, avoid mines while navigating restricted areas or channels, such entering or leaving port
Mine Neutralization – Remotely Operated Vehicle Sonar (ASQ-235 [AQS-20], SLQ-48)	Ship, small boat, helicopter crews locate, disable mines using remotely operated underwater vehicles
Mine Countermeasure – Towed Mine Neutralization	Helicopter aircrews, manned and unmanned vehicles tow systems through the water which are designed to disable or trigger mines.
Underwater Demolition Qualification/ Certification	Navy divers conduct various levels of training and certification in placing underwater demolition charges
Submarine Mine Exercise	Submarine crews practice detecting mines in designated areas
Surface Ship Object Detection	Ship crews detect and avoid mines while navigating restricted areas or channels using active sonar.

3.1.8 Expeditionary Warfare

Table 17 provides summaries of training activities in support of expeditionary warfare.

Table 17. Expeditionary warfare exercises.

Activity Name	Activity Description
Naval Special Warfare	
Personnel Insertion/Extraction	Military personnel train for covert insertion and extraction into target areas using helicopters, fixed-wing (insertion only), small boats, and submersibles.
Parachute Insertion	Military personnel train for covert insertion into target areas using parachutes.

3.1.9 Major Training Exercises and Other Training Activities

Major training exercises provide multi-service and joint participation in realistic maritime and expeditionary training that is designed to replicate the types of events and challenges that could be faced during real-world contingency operations. Major training exercises also include providing training to submarine, ship, aircraft, and special warfare forces in mission tactics, techniques, and procedures. Table 18 provides summaries of Major Training and Other Training Activities.

Table 18. Major training exercises and other training activities.

Activity Name	Activity Description
Major Training Activities	
Joint Expeditionary Exercise	A 10-day exercise that could include a Carrier Strike Group and Expeditionary Strike Group, Marine Expeditionary Units, Army Infantry Units, and Air Force aircraft together in a joint environment that includes planning and execution efforts as well as military training activities at sea, in the air, and ashore.
Joint Multi-Strike Group Exercise	A 10-day joint exercise, in which up to three carrier strike groups would conduct training exercises simultaneously.
Marine Air Ground Task Force Exercise (Amphibious) – Battalion	A 10-day exercise that conducts over the horizon, ship to objective maneuver for the elements of the Expeditionary Strike Group and the Amphibious Marine Air Ground Task Force. The exercise utilizes all elements of the Marine Air Ground Task Force (Amphibious), conducting training activities ashore with logistic support of the Expeditionary Strike Group and conducting amphibious landings.
Other Training Activities	
Surface Ship Sonar Maintenance	Maintenance of surface ship sonar and other system checks conducted pierside or at sea.
Submarine Sonar Maintenance	Maintenance of submarine sonar and other system checks conducted pierside or at sea

Activity Name	Activity Description
Small Boat Attack	Afloat units defend against small boat or personal water craft attack.
Submarine Navigation	Submarine crews operate sonar for navigation and detection while transiting into and out of port during reduced visibility.
Search and Rescue at Sea	Helicopter and ship crews rescue military personnel at sea.
Precision Anchoring	Surface ship crews release and retrieve anchors in designated locations.
Direct Action (Tactical Air Control Party)	Military personnel control combat support aircraft; providing airspace de-confliction and terminal control for Close Air Support.
Intelligence, Surveillance, Reconnaissance	Personnel train to collect and report battlefield intelligence.
Underwater Survey	Navy divers survey underwater conditions and features in preparation for insertion, extraction, or intelligence, surveillance, and reconnaissance activities.
Unmanned Aerial Vehicle Training and Certification	Units conduct training with unmanned aerial vehicles from a variety of platforms including surface ships and submarines.
Unmanned Underwater Vehicle Training	Units conduct training with unmanned underwater vehicles from variety of platforms, including surface ships, small boats, and submarines

3.2 Mariana Islands Testing Activities

The Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (e.g., missiles, radar, and sonar), and platforms (e.g., surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions and give a technological edge over adversaries.

The individual commands within the research and acquisition community included in this opinion are Naval Air Systems Command, Naval Sea Systems Command, the Office of Naval Research.

The Navy operates in an ever-changing strategic, tactical, and funding and time-constrained environment. Testing activities occur in response to emerging science or fleet operational needs. For example, future Navy experiments to develop a better understanding of ocean currents may be designed based on advancements made by non-government researchers not yet published in the scientific literature. Similarly, future but yet unknown Navy operations within a specific geographic area may require development of modified Navy assets to address local conditions. Such modifications must be tested in the field to ensure they meet fleet needs and requirements.

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

As the Navy's Science and Technology provider, Office of Naval Research provides technology solutions for Navy and Marine Corps needs. The Office of Naval Research's mission, defined by law, is to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Further, the Office of Naval Research manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test, and evaluation. The Office of Naval Research events include research, development, test, and evaluation activities; surface processes acoustic communications experiments; shallow and deep water acoustic communications experiments; sediment acoustics experiments; shallow and deep water acoustic propagation experiments; and long-range acoustic propagation experiments.

3.2.1 Naval Air Systems Command Testing Activities

Naval Air Systems Command testing activities generally fall in the primary mission areas used by the fleets. Naval Air Systems Command activities include, but are not limited to, the testing of new aircraft platforms, weapons, and systems before those platforms, weapons and systems are delivered to the fleet. In addition to the testing of new platforms, weapons, and systems, Naval Air Systems Command also conducts lot acceptance testing of weapons and systems, such as sonobuoys.

The majority of testing and development activities (Table 19) conducted by Naval Air Systems Command are similar to fleet training activities, and many platforms (e.g., Maritime Patrol Aircraft) and systems (e.g., sonobuoys) currently being tested are already being used by the fleet or will ultimately be integrated into fleet training activities. However, some testing and development may be conducted in different locations and in a different manner than the fleet and therefore, though the potential environmental effects may be the same, the analysis for those activities may differ.

Table 19. Naval air systems command testing activities.

Testing Event	Description	Weapons/Rounds/ Sound Source
Anti-Surface Warfare		
Air-to-Surface Missile Testing (Explosive)	Similar to training event missile exercise air-to-surface. May involve fixed-wing and rotary- wing aircraft launching missiles at surface maritime targets to evaluate weapons system or as part of another systems integration test	Explosive missiles
Anti-Submarine Warfare		
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	Evaluates sensors, systems used by maritime patrol aircraft to detect and track submarines to ensure aircraft systems used to deploy tracking systems perform to specifications meeting operational requirements	Exercise (Non-explosive) torpedoes
Anti-Submarine Warfare Torpedo Test	Similar to training event torpedo exercise. Evaluates anti-submarine warfare systems onboard rotary-wing and fixed-wing aircraft and ability to search for, detect, classify, localize, track, attack submarine or similar target	Directional Command Activated Sonobuoy System active sonobuoys, Improved Extended Echo Ranging sonobuoys (2 detonations per buoy), High Duty Cycle sonobuoys, various Signal Underwater Sound devices, Multi-static Active Coherent sonobuoys
Electronic Warfare		
Intelligence, Surveillance, Reconnaissance/ Electronic Warfare Testing (previously named Broad Area Maritime Surveillance Testing – MQ-4C)	Aircrews use all available sensors to collect data on threat vessels.	

3.2.2 Naval Sea Systems Command Testing Activities

Naval Sea Systems Command testing activities are aligned with its mission of new ship construction, life cycle support, and weapon systems development. Each major category of Naval Sea Systems Command activities is described below in

Table 20.

Table 20. Naval sea systems command testing activities.

Activity Name	Activity Description
Anti-Submarine Warfare	
Anti-Submarine Warfare Mission Package Testing	Ships and their supporting platforms (e.g., helicopters and unmanned aerial systems) detect, localize, prosecute submarines
At-Sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment
Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive and non- explosive torpedoes against artificial targets.
Torpedo (Non-explosive) Testing	Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels
Electronic Warfare	
Radar and Other System Testing (including high-energy laser use)	Test may occur aboard a ship against drones, small boats, rockets, missiles, or other targets, and include radiation of military or commercial radar, communication systems (or simulators), or high-energy lasers.
Mine Warfare	
Mine Countermeasure and Neutralization Testing (previously covered under Mine Countermeasure Mission Package Testing)	Air, surface, subsurface vessels neutralize threat mines and mine-like objects
Surface Warfare	
Kinetic Energy Weapon Testing	A kinetic energy weapon uses stored energy released in a burst to accelerate a projectile.
Vessel Evaluation *(previously named Life Cycle Activities)*	
Undersea Warfare Testing (previously covered under torpedo testing)	Ships demonstrate capability of countermeasure systems and underwater surveillance, weapons engagement, communications systems. Tests ships' ability to detect, track, engage undersea targets
Other Testing Activities	
Simulant Testing	The capability of surface ship defense systems to detect and protect against chemical and biological attacks are tested.

3.2.3 Office of Naval Research Activities

The Office of Naval Research Activities conducts acoustic and oceanographic research. Research of oceanographic processes use active transmissions, typically high- frequency (38 kHz

and above) oceanographic measurement devices. Devices are deployed from ships, unmanned underwater vehicles and on moored platforms.

3.3 Classification of Navy Sonar and Explosive Sources into Bins

The Navy developed a series of source classifications, or source bins, in order to better organize and facilitate the analysis of, and implementation of mitigation for, approximately 300 individual sources of underwater sound deliberately employed by the Navy including sonars, other transducers (devices that convert energy from one form to another—in this case, to sound waves), and explosives. Non-impulsive sources are grouped into bins based on the frequency, source level when warranted, and how the source would be used. Low-frequency sources operate below 1 kilohertz (kHz); mid-frequency sources operate at or above 1 kHz, up to and including ten kHz; high-frequency sources operate above ten kHz, up to and including 100 kHz; and very high-frequency sources operate above 100 kHz, but below 200 kHz. Impulsive bins are based on the NEW of the munitions or explosive devices.

Sonar source bins are described in Table 21, along with a comparison of activity levels between ongoing activities (MITT Phase II) and the proposed action (MITT Phase III). For all sonar bins that use hours as a metric, total cumulative sonar hours decreased by approximately 35 percent from 13,672 hours in 2015 to 8,908 hours in the 2019 proposed action.

Table 21. Description of Navy sonar source bins and comparison of annual activity levels by bin between ongoing activities and the proposed action.

Source Class Category	Bin	Unit*	Description	Training & Testing	
				Ongoing Activities	Proposed Action
Low-Frequency (LF): Sources that produce signals less than one kHz	LF4	H	Low-frequency sources equal to 180 dB and up to 200 dB	123	1
	LF5	H	Low-frequency sources less than 180 dB	11	10
	LF6	H	Low-frequency sonar (e.g., ASW sonar associated with the Littoral Combat Ship)	40	0
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between one and ten kHz	MF1	H	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-60)	1,872	1,818
	MF1K	H	Kingfisher mode associated with MF1 Sonars	0	3
	MF2	H	Hull-mounted surface ship sonars (e.g., AN/SQS-56)	625	0
	MF3	H	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	192	228
	MF4	H	Helicopter-deployed dipping sonars (e.g., AN/AQS-22 and AN/AQS-13)	214	185
	MF5	C	Active acoustic sonobuoys (e.g., DICASS)	2,588	2,094
	MF6	C	Active underwater sound signal devices (e.g., MK 84)	33	74
	MF8	H	Active sources (greater than 200 dB) not otherwise binned	123	0
	MF9	H	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	47	29

Source Class Category	Bin	Unit*	Description	Training & Testing	
				Ongoing Activities	Proposed Action
	MF10	H	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	231	0
	MF11	H	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	324	304
	MF12	H	High duty cycle - variable depth sonar	656	616
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	H	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	113	73
	HF3	H	Other hull-mounted submarine sonars (classified)	0	4
	HF4	H	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	1,060	1,472
	HF5	H	Active sources (greater than 200 dB) not otherwise binned	336	0
	HF6	H	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	1,173	309
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	H	Mid-frequency Deep Water Active Distributed System	144	192
	ASW2	C	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	660	554
	ASW3	H	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	3,935	3,124
	ASW4	C	Mid-frequency expendable active acoustic device countermeasures (e.g., MK3)	11	332
	ASW5	H	Mid-frequency sonobuoys with high duty Cycles	0	50
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	C	Lightweight torpedo (e.g., MK 46, MK 54, or Anti Torpedo Torpedo)	115	71
	TORP2	C	Heavyweight torpedo (e.g., MK 48)	62	62
	TORP3	C	Heavyweight torpedo (e.g., MK 48)	0	6
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	H	High-frequency sources with short pulse lengths, narrow beam widths, and focused beam patterns	0	4
Acoustic Modems (M): Systems used to transmit data through the water	M3	H	Mid-frequency acoustic modems (greater than 190 dB)	112	31
Swimmer Detection Sonar (SD): Used to detect divers and submerged swimmers	SD1	H	High-frequency and very high-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security	2,341	0
Air Guns (AG): Used during swimmer defense and diver deterrent training and testing activities	AG	C	Small underwater air guns	308	0
Synthetic Aperture Sonars (SAS):	SAS2	H	High-frequency Synthetic Aperture Sonar Systems	0	449

Source Class Category	Bin	Unit*	Description	Training & Testing	
				Ongoing Activities	Proposed Action
Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS4	H	Mid-frequency to high-frequency broadband mine countermeasure sonar	0	6

Notes: * H = hours, C = count (e.g., number of individual pings or individual sonobuoys)

In addition to the acoustic sources described above, there are other in-water, active acoustic sources from MITT activities that were not quantitatively analyzed using NAEMO (Table 22).

Table 22. Acoustic sources that were not included in the Navy's quantitative analysis.

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

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

Explosive source bins are described in Table 23, along with a comparison of activity levels between ongoing activities (MITT Phase II) and the proposed action (MITT Phase III). After analyzing the explosive activities conducted pursuant to the NMFS 2015 LOA and 2017 biological opinion, the Navy discovered that some explosive sources were incorrectly classed into bins with greater NEW than actually is present in the munition. For example, 20 millimeter (mm) rounds were previously considered in bin E1 (defined as 0.1–0.25 pounds (lbs) NEW), but have less than 0.1 lb. of NEW (defined as bin E0). Most bombs were previously analyzed as bin E12 (to account for the largest potential for environmental impact), whereas many fall within bins E9 and E10. For this consultation, munitions were divided into more appropriate bins based on current and anticipated weapon inventory.

Table 23. Description of Navy explosive source bins and comparison of annual activity levels by bin between ongoing activities and the proposed action.

Bin	*Net Explosive Weight[1] (lb.)*	*Example Explosive Source*	*Training and Testing*	
			Ongoing Activities	*Proposed Action*
E1	0.1–0.25	Medium-caliber projectiles	10,140	768
E2	> 0.25–0.5	Grenade	106	400
E3	> 0.5–2.5	57 mm projectiles	932	683
E4	> 2.5–5	Mine Neutralization Charge	420	44
E5	> 5–10	5 inch projectiles	684	1,221
E6	>10-20	Hellfire missile	76	29
E8*	> 60–100	250 lb. bomb; Lightweight torpedo	16	134
E9*	> 100-250	500 lb. bomb	4	110
E10*	> 250–500	1,000 lb. bomb	12	78
E11	> 500–650	Heavyweight torpedo	6	5
E12*	> 650–1,000	2,000 lb. bomb	184	48

[1] Net Explosive Weight refers to the amount of explosives; the actual total weight of a munition may be larger due to other components (ex., casing, fins, and guidance).
* Ongoing Activities were modeled assuming ALL bombs were bin E12. For the Proposed Action, a more accurate allocation of bomb types between bins E8, E9, E10, and E12 was used.

In addition to the explosives quantitatively analyzed for impacts to ESA-listed species shown in Table 23, the Navy uses some very small impulsive sources (less than 0.1 lb. NEW), categorized in bin E0, that were not quantitatively analyzed by the Navy for potential exposure to ESA-listed species.

3.4 Proposed Training Activity Levels

Table 24 provides a summary of MITT training activities (as described in Section 3.1 above) including the duration of event, source bins used, location, number of events per year, and ordnance used, if any. This table also compares ongoing MITT Phase II activity levels with the Navy's proposed activity levels for MITT Phase III (note: blue shading indicates decrease from previous levels; red shading indicates increase from previous levels).

Table 24. Annual training activity levels under the proposed action compared to ongoing activity levels.

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Joint Expeditionary Exercise	10 days	MF1, MF4, MF5, MF12, ASW2, ASW3	Action area; Mariana Islands Range Complex (MIRC)	1	Note 1	1	Note 1
Joint Multi-Strike Group Exercise	10 days	MF1, MF3, MF4, MF5, MF11, MF12, ASW2, ASW3, ASW4, HF1	Action area; MIRC	1	Note 1	1	Note 1
Marine Air Ground Task Force Exercise (Amphibious) – Battalion	10 days	MF1, MF4, MF12, ASW3	Action area to nearshore; MIRC; Tinian; Guam; Rota; Saipan; FDM	4	Note 1	4	Note 1
Air Combat Maneuver	1–2 hours	None	Action area > 12 nautical miles (NM) from land: Special Use Airspace	4,800	None	3,800	None
Air Defense Exercise (ADEX)	1–4 hours	None	Action area > 12 NM from land: Special Use Airspace	100	None	100	None
Air Intercept Control (AIC)	1–2 hours	None	Action area >12 NM from land: Special Use Airspace	4,800	None	5,300	None
Gunnery Exercise (GUNEX)(Air-to-Air)- Medium caliber	1–2 hours	None	Action area > 12 NM from land: Special Use Airspace	36	9,000 rounds	36	9,000 rounds

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Gunnery Exercise (GUNEX) (Surface-to-Air)- medium caliber	1–2 hours	None	Action area > 12 NM from land: Special Use Airspace	12	24,000 rounds	19	38,000 rounds
Gunnery Exercise (GUNEX) (Surface-to-Air)- large caliber	Up to 3 hours	None	Action area > 12 NM from land: Special Use Airspace	5	40 rounds	9	90 rounds
Missile Exercise (Air-to- Air)	1–2 hours	None[3]	Action area > 12 NM from land: Special Use Airspace	18	36 explosive missiles	18	36 explosive missiles
Missile Exercise (Surface- to-air)	1–2 hours	None[3]	Action area > 12 NM from land: Special Use Airspace	15	15 explosive missiles	27	27 explosive missiles
Naval Surface Fire Support Exercise (FIREX) – Land-based target (Land)	4–6 hours	None	FDM	10	1,800 non-explosive rounds, 1,000 explosive rounds	15	4,200 explosive rounds
Amphibious Rehearsal, No Landing	1–2 days	None	Action area and nearshore	12	None	12	None
Amphibious Assault	Up to 2 weeks	None	MIRC; Tinian; Guam	6	Blanks; Simunitions	6	Blanks; Simunitions
Amphibious Raid	4–8 hours	None	MIRC; Tinian; Guam; Rota	6	Blanks; Simunitions	6	Blanks; Simunitions
Noncombatant Evacuation Operation	5 days	None	MIRC; Tinian; Guam; Rota	5	Blanks; Simunitions	5	Blanks; Simunitions
Humanitarian Assistance/ Disaster Relief Operations	Up to 2 weeks	None	MIRC; Tinian; Guam; Rota	5	Blanks; Simunitions	5	Blanks; Simunitions

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Unmanned Aerial Vehicle – Intelligence, Surveillance, and Reconnaissance	Varies	None	MIRC; Special Use Airspace	100	None	100	None
Special Purpose Marine Air Ground Task Force Exercise	10 days	None	Action area to nearshore; MIRC; Tinian; Guam; Rota; Saipan	2	Note 1	2	Note 1
Tracking Exercise – Helicopter (TRACKEX – Helo)	2–4 hours	MF4, MF5	Action area > 3 NM from land; Transit Corridor	62	None/ REXTORP	10	None/ REXTORP
Torpedo Exercise – Helicopter (TORPEX – Helo)	2–5 hours	MF4, MF5, TORP1	Action area > 3 NM from land	4	4 EXTORP	6	6 EXTORP
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – Maritime Patrol Aircraft)	2–8 hours	MF5	Action area > 3 NM from land	34	None/ REXTORP	36	None/ REXTORP
Torpedo Exercise – Maritime Patrol Aircraft (TORPEX – Maritime Patrol Aircraft)	2–8 hours	MF5, TORP1	Action area > 3 NM from land	4	4 EXTORP	6	6 EXTORP
Tracking Exercise – Surface (TRACKEX – Surface)	2–4 hours	ASW1, ASW3, MF1, MF11, MF12	Action area > 3 NM from land (see note 4 below regarding MF1 activity level with the humpback whale GMAs)	CG/DDG 92 events FFG 30 events LCS 10 Events	None/ REXTORP	91	None/ REXTORP

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Torpedo Exercise – Surface (TORPEX – Surface)	2–5 hours	ASW3, MF1, MF5, TORP1	Action area > 3 NM from land	3	3 EXTORP	6	6 EXTORP
Tracking Exercise – Submarine (TRACKEX – Sub)	8 hours	ASW4, HF1, HF3, MF3	Action area > 3 NM from land; Transit Corridor	12	None	4	None
Torpedo Exercise – Submarine (TORPEX – Sub)	8 hours	ASW4, HF1, MF3, TORP2	Action area > 3 NM from land	10	40 EXTORP	9	36 EXTORP
Small Joint Coordinated ASW exercise- (e.g., Multi Sail/GUAMEX/ SWATT)	5 days	ASW2, ASW3, ASW4, HF1, MF1, MF3, MF4, MF5, MF11, MF12	Action area > 3 NM from land (see note 4 below regarding MF1 activity level with the humpback whale GMAs)	Note 2	None	3	None
Electronic Warfare Operations (EW Ops)	1–2 hours	None	Action area	480	None	522	None
Counter Targeting Flare Exercise (FLAREX) – Aircraft	1–2 hours	None	Action area > 12 NM from land	3,200	25,600 rounds	2,200	17,600 rounds
Counter Targeting Chaff Exercise (CHAFFEX) – Ship	1–2 hours	None	Action area > 12 NM from land	40	240 rounds	60	360 rounds
Counter Targeting Chaff Exercise (CHAFFEX) – Aircraft	1–2 hours	None	Action area > 12 NM from land	3,200	25,600 rounds	2,200	17,600 rounds
Personnel Insertion/ Extraction	2–8 hours	None	MIRC; Guam; Tinian; Rota	240	None	365	None

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Parachute Insertion	2–8 hours	None	MIRC parachute drop zones; Guam; Tinian; Rota	20	None	64	None
Civilian Port Defense	Multiple days	HF4, SAS2	MIRC, Mariana littorals, Inner and Outer Apra Harbor	1	None	1	None
Mine Laying	1 hour	None	MIRC Warning Areas, Special Use Airspace, FDM	4	480 mine shapes	4	480 mine shapes
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Up to 4 hours	E5, E6	Agat Bay underwater detonation site (UNDET) Piti and Outer Apra Harbor UNDETs	20	20 explosive charges	20	20 explosive charges
Limpet Mine Neutralization System	2 hours	E0	Mariana littorals; Inner and Outer Apra Harbor	40	40 charges	60	60 charges
Airborne Mine Countermeasure – Towed Mine Detection	1.5 – 4 hours	None	Action area; nearshore	4	None	4	None
Mine Countermeasure Exercise – Towed Sonar (AQS-20, LCS)	1–4 hours	HF4	Action area, Apra Harbor	4	None	4	None

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Mine Countermeasure Exercise – Surface Ship Sonar (SQQ-32, MCM)	Up to 15 hours	HF4	Action area, Apra Harbor	4	None	4	None
Mine Neutralization – Remotely Operated Vehicle Sonar (ASQ-235 [AQS-20], SLQ-48)	1–4 hours	E4	Action area, Mariana littorals, and Outer Apra Harbor	4	4 explosive neutralizers	4	4 explosive neutralizers
Mine Countermeasure – Towed Mine Neutralization	Up to 12 hours	None	Action area, Apra Harbor	4	None	4	None
Underwater Demolition Qualification/ Certification	Varies	E5, E6	Agat Bay UNDET, Piti and Outer Apra Harbor UNDETs	30	30 explosives charges	45	45 explosive charges
Submarine Mine Exercise	Varies	HF1	Action area, Mariana Littorals	16	None	1	None
Surface Ship Object Detection	Up to 15 hours	MF1K	Action area	Not previously analyzed	None	6	None
Bombing Exercise (BOMBEX) (Air-to-Ground [A-G])	1–2 hours	None[5]	FDM	2,300	2,670 non-explosive bombs 6,242 explosive bombs	2,300	2,670 non-explosive bombs 6,242 explosive rounds
					24,000		24,000

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Gunnery Exercise (GUNEX) (Air-to-Ground)	1 hour	None[5]	FDM	96	small-caliber 94,150 med-caliber (non-explosive) 17,350 med-caliber (explosive) 200 large-caliber (explosive)	96	small-caliber 94,650 med-caliber (non-explosive) 17,500 med-caliber (explosive) 200 large-caliber (explosive)
Missile Exercise (MISSILEX) (Air-to-Ground)	1–2 hours	None[4]	FDM	85	2,000 explosive rockets 85 explosive missiles	115	2,000 explosive rockets 115 explosive missiles
Gunnery Exercise (GUNEX) (Air-to-Surface) – Small- caliber	1 hour	None	Action area > 12 NM from land, Special Use Airspace	242	48,040 rounds	321	128,400 rounds
Gunnery Exercise (GUNEX) (Air-to-Surface) – Medium-caliber	1 hour	E1, E2	Action area > 12 NM from land, Special Use Airspace	295	29,500 non-explosive 7,150 explosive rounds	120	3,600 explosive rounds
Missile Exercise (Air-to- Surface) – Rocket (MISSILEX [A-S] – Rocket)	1 hour	E3	Action area > 12 NM from land, Special Use Airspace	3	114 explosive rockets	111	323 explosive rockets 1,786 non-explosive rockets
Missile Exercise (Air-to- Surface) (MISSILEX [A-S])	2 hours	E6, E8, E10	Action area > 12 NM from land, Special Use Airspace	20	20 explosive missiles	10	18 explosive missiles
Laser Targeting (at sea)	1–2 hours	None	Action area > 12 NM from land, Special Use Airspace	600	None	600	None

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Bombing Exercise (BOMBEX) (Air-to-Surface)	1 hour	E9, E10, E12	Action area > 50 NM from land, Special Use Airspace	37	368 non-explosive bombs 184 explosive bombs	37	368 non-explosive bombs 184 explosive bombs
Missile Exercise (Surface- to-Surface) (MISSILEX [S- S])	2–5 hours	E6, E10	Action area > 50 NM from land, Special Use Airspace	12	12 explosive missiles	28	28 explosive missiles
Gunnery Exercise (GUNEX) (Surface-to- Surface) Ship – Large- caliber	Up to 3 hours	E5	Action area > 12 NM from land, Special Use Airspace	140	5,198 non-explosive rounds 500 explosive rounds	255	24,480 non-explosive rounds 765 explosive rounds
Gunnery Exercise (GUNEX) (Surface-to- Surface) Ship – Small- and Medium-caliber	2–3 hours	E1	Action area > 12 NM from land, Special Use Airspace	100	21,000 non-explosive rounds 900 explosive rounds	234	250,800 non-explosive rounds 720 explosive rounds
Sinking Exercise (Representative ordnance. Actual ordnance used will vary)	4–8 hours, possibly over 1–2 days	E5, E8, E10, E11, E12, TORP2	Action area > 50 NM from land and > 1,000 fathoms depth	2	Explosive Ordnance: 28 bombs 42 missiles 800 lg caliber rounds 2 torpedoes 4 demolition charges	1	Explosive Ordnance: 28 bombs 42 missiles 800 lg caliber rounds 2 torpedoes 4 demolition charges
Gunnery Exercise (GUNEX) (Surface-to- Surface) Boat – Medium- caliber	1 hour	E2	Action area Special Use Airspace > 12 NM from land; Transit Corridor	10	2,000 non-explosive rounds 100 explosive rounds	20	4,000 non-explosive rounds 200 explosive rounds

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Gunnery Exercise (GUNEX) (Surface-to- Surface) Boat – Small- caliber	1 hour	None	Action area Special Use Airspace > 12 NM from land; Transit Corridor	40	36,000 rounds	43	36,600 rounds
Maritime Security Operations	Up to 3 hours	E2	Action area; MIRC	40	200 G911 anti-swimmer grenades	40	200 G911 anti-swimmer grenades
Direct Action (Tactical Air Control Party)	Multiple days	None[5]	FDM	18	18,000 small-caliber rounds 600 explosive grenade/ mortar	18	30,000 small-caliber rounds 1,000 medium-caliber rounds (explosive) 1,000 explosive grenade/ mortar
Intelligence, Surveillance, Reconnaissance	Multiple days	None	MIRC; Guam; Tinian; Rota; Saipan	16	None	44	None
Precision Anchoring	Up to 1 hour	None	Apra Harbor; Mariana Islands anchorages	18	None	18	None
Search and Rescue At Sea	Up to 3 days	None	Action area	40	None	45	None
Submarine Navigation	Up to 2 hours	HF1, MF3	Action area, Apra Harbor, and Mariana littorals	8	None	8	None
Small Boat Attack	6 hours	None	Action area > 3 NM from land	6	2,100 small-caliber rounds	27	3,150 small-caliber rounds

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
			Action area	12	4,000 blank rounds		6,000 blank rounds
Submarine Sonar Maintenance	Up to 1 hour	MF3	Action area > 3 NM from land; Inner Apra Harbor; Transit Corridor	48	None	86	None
Surface Ship Sonar Maintenance	Up to 4 hours	MF1	Action area > 3 NM from land; Inner Apra Harbor; Transit Corridor	42	None	44	None
Underwater Survey	4 hours	None	Mariana littorals	16	None	32	None
Unmanned Aerial Vehicle Training and Certification	2 days	None	Action area; MIRC Airfields (Orote Point, Guam; Northwest, Guam; North, Tinian) Special Use Airspace	1,000	None	951	None
Unmanned Underwater Vehicle Training	Up to 24 hours	FLS2, M3, SAS2, SAS4	MIRC; Apra Harbor and Mariana littorals	N/A	N/A	64	None
Air-to-Surface Missile Testing (Explosive)	2–4 hours	E10	Action area > 50 NM from land, Special Use Airspace	8	8 missiles (up to 4 explosive)	4	4 missiles (up to 4 explosive)

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	8 hours	ASW2, ASW5, E1, E3, MF5, MF6	Action area > 3 NM from land	188	240 explosive sonobuoys 553 explosive SUS	26	392 explosive SUS
Anti-Submarine Warfare Torpedo Test	2–6 hours	MF5, TORP1	Action area > 3 NM from land	40	40 EXTORP	20	20 REXTORP
Intelligence, Surveillance, Reconnaissance/ Electronic Warfare Testing (previously named Broad Area Maritime Surveillance Testing – MQ-4C)	2–20 hours	None	Action area > 3 NM from land	10	None	20	None
Anti-Submarine Warfare Mission Package Testing	1–2 weeks, with 4–8 hours of active sonar use with intervals of non-activity	ASW1, ASW2, ASW3, ASW5, MF12, MF4, MF5, TORP1	Action area; MIRC	33	None	100	8 torpedoes (non- explosive)
At-Sea Sonar Testing	4 hours to 11 days	HF1, HF6, M3, MF3, MF9	Action area	20	None	7	None

[1] Sonar source bins represent acoustic stressors and explosive source bins represent explosive stressors.

[2] Ongoing Activities = 2015 MITT ROD & NMFS 2017 Biological Opinion; Proposed Action = Navy's 2019 Final Supplemental EIS/OEIS & the Navy's 2019 BA.

[3] In-Air detonations only.

[4] Includes up to 20 hours annually of MF1 sonar within the designated humpback whale geographic mitigation areas (Chalan Kanoa Reef and Marpi Reef) combined from December-April. The 20 hours can be from TRACKEX events, a Small Joint Coordinated ASW exercise, or some combination of these activities (Navy 2020b).

[5] Detonations occur on land.

3.5 Proposed Testing Activity Levels

Table 25 provides a summary of MITT testing activities (as described in Section 3.2 above) including the duration of event, source bins used, location, number of events per year, and ordnance used, if any. This table also compares ongoing MITT Phase II activity levels with the Navy's proposed activity levels for MITT Phase III.

Table 25. Annual testing activity levels under the proposed action compared to ongoing activity levels.

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
NAVAL AIR SYSTEMS COMMAND							
Air-to-Surface Missile Testing (Explosive)	2–4 hours	E10	Action area > 50 NM from land, Special Use Airspace	8	8 missiles (up to 4 explosive)	4	4 missiles (up to 4 explosive)
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	8 hours	ASW2, ASW5, E1, E3, MF5, MF6	Action area > 3 NM from land	188	240 explosive sonobuoys 553 explosive SUS	26	392 explosive SUS
Anti-Submarine Warfare Torpedo Test	2–6 hours	MF5, TORP1	Action area > 3 NM from land	40	40 EXTORP	20	20 REXTORP

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Intelligence, Surveillance, Reconnaissance/ Electronic Warfare Testing (previously named Broad Area Maritime Surveillance Testing – MQ-4C)	2–20 hours	None	Action area > 3 NM from land	10	None	20	None
NAVAL SEA SYSTEMS COMMAND							
Anti-Submarine Warfare Mission Package Testing	1–2 weeks, with 4–8 hours of active sonar use with intervals of non- activity	ASW1, ASW2, ASW3, ASW5, MF12, MF4, MF5, TORP1	Action area; MIRC	33	None	100	8 torpedoes (non-explosive)
At-Sea Sonar Testing	4 hours to 11 days	HF1, HF6, M3, MF3, MF9	Action area	20	None	7	None
Torpedo (Explosive) Testing	1–2 days daylight hours	ASW3, HF1, HF6, MF1, MF3, MF4, MF5, MF6, TORP1, TORP2, E8, E11	MIRC			3	6 explosive 12 non-explosive

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Torpedo (Non-explosive) Testing	Up to 2 weeks	ASW3, ASW4, HF1, HF6, LF4, MF1, MF3, MF4, MF5, MF6, TORP1, TORP2, TORP3	MIRC	2	20 torpedoes (up to 8 non-explosive)	7	37 non-explosive
Radar and Other System Testing (including high-energy laser use)	12 hours per day over a 7-day period	None	Action area	Not Pre-viously Analyzed	Not Pre-viously Analyzed	60	None
Mine Counter- measure and Neutralization Testing (previously covered under Mine Countermeasure Mission Package Testing)	1–10 days with inter-mittent use	HF4, E4	MIRC	32	48 neutralizers (up to 24 explosive)	3	40 explosive neutralizers
Kinetic Energy Weapon Testing	1 day	None[3]	Action area	50	2,000 projectiles	9	180 explosive projectiles 360 non-explosive projectiles
				1-time only event	5,000 projectiles		
Undersea Warfare Testing (previously covered under torpedo testing)	Up to 10 days	HF4, MF1, MF4, MF5, TORP1	MIRC	2 (Note 1)	20 torpedoes (up to 8 explosive)	1	8 non-explosive torpedoes

Activity	Typical Duration of Event	Source Bin[1]	Location	Ongoing Activities [2]		Proposed Action [2]	
				No. of Events (per yr)	No. of Ordnance (per yr)	No. of Events (per yr)	No. of Ordnance (per yr)
Simulant Testing	3 days	None	Action area	Not Previously Analyzed	None	100	None
OFFICE OF NAVAL RESEARCH							
Acoustic and Oceanographic Research (previously named North Pacific Acoustic Lab Philippine Sea 2018–19 Experiment, Deep Water	1 – 2 weeks	None	Action area	1	None	1	None

[1] Sonar source bins represent acoustic stressors and explosive source bins represent explosive stressors.

[2] Ongoing Activities = 2015 MITT ROD & NMFS 2017 Biological Opinion; Proposed Action = Navy's 2019 Final Supplemental EIS/OEIS & the Navy's 2019 BA.

[3] In-Air detonations only

Note 1: Torpedo (Explosive) Testing, Torpedo (Non-explosive) Testing, and Undersea Warfare Testing were previously covered under torpedo testing in the NMFS 2017 Biological Opinion.

3.6 Standard Operating Procedures and Mitigation Measures

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

3.6.1 Standard Operating Procedures

When conducting training and testing activities, the Navy implements standard operating procedures to provide for safety and mission success. Navy standard operating procedures are broadcast via numerous naval instructions and manuals to ensure compliance. Because they are essential to safety and mission success, standard operating procedures are part of the Proposed Action. Standard operating procedures that may minimize or avoid effects to ESA-listed species analyzed in this document are presented in the sections below.

Vessel Safety

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

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

Weapons Firing Safety

Most weapons firing activities that involve the use of explosive munitions are conducted during daylight hours. In addition, pilots of Navy aircraft are not authorized to expend ordnance, fire missiles, or drop other airborne devices through extensive cloud cover where visual clearance for non-participating aircraft and vessels in the air and on the sea surface is not possible. The two exceptions to this requirement are: (1) when operating in the open ocean, clearance for non-participating aircraft and vessels in the air and on the sea surface through radar surveillance is acceptable; and (2) when the Officer Conducting the Exercise or civilian equivalent accepts responsibility for the safeguarding of airborne and surface traffic. During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. Weapons firing safety standard operating procedures could reduce adverse effects to marine mammals, sea turtles, fish, and corals by reducing the potential for physical disturbance and strike, entanglement, and ingestion of applicable targets and any associated decelerators/parachutes.

Target Deployment and Retrieval Safety

The deployment and retrieval of targets is dependent upon environmental conditions. Firing exercises involving the deployment and retrieval of targets from small boats are typically conducted in daylight hours in Beaufort Sea State number four conditions (i.e., winds 11 to 16

knots, small waves one to four feet (ft.) becoming longer, numerous whitecaps) or better to ensure safe operating conditions during target deployment and recovery. This standard operating procedure could reduce adverse effects to marine mammals and sea turtles through a reduction in the potential for interaction with weapons firing activities associated with the use of applicable targets.

Towed In-Water Device Safety

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

Amphibious Assault and Amphibious Raid Procedures

All established harbor navigation rules are observed during amphibious assault and amphibious raid training activities, when applicable. The Navy conducts a hydrographic survey prior to amphibious assault and amphibious raid training activities involving beach landings by large amphibious vehicles (e.g., Air Cushioned Landing Craft). During the surveys, personnel identify and designate vessel traffic lanes that are free of coral, hard bottom substrate, and obstructions that could present personnel and equipment safety concerns. The Navy does not conduct hydrographic surveys for beach landings with small boats, such as Rigid Hull Inflatable Boats, which have a much smaller draft than large amphibious vehicles. Large amphibious vehicle beach landings and departures are scheduled at high tide, and vehicles stay fully on cushion or hover when over shallow reefs to avoid corals, hard bottom, and other substrate that could potentially damage equipment. This standard operating procedure could reduce adverse effects to seafloor resources and ESA-listed species that inhabit, shelter in, or feed among them, through a reduction in the potential for physical disturbance and strike during amphibious assault and amphibious raid activities.

Due to the accidental grounding of the French Navy Landing Craft that occurred on May 12, 2017, the Navy has implemented additional standard operating procedures for amphibious assault and raid activities. The Navy requires the following standard operating procedures for amphibious landings at Reserve Craft Beach, located within Apra Harbor (see Figure 25 below): (1) Concept of Operations for the event and for notification and coordination with Naval Base Guam Operations Officer, (2) presence of craft master who will coordinate planned routes with MIRC (Mariana Islands Range Complex) Ops and Naval Base Guam, (3) presence of a beach master (observers) to assist in approach to shore and restore beach to original condition, and (4) distribution of the Reserve Craft Beach Training Aid to all vessel captains participating in any training event in the vicinity of Reserve Craft Beach.

Underwater Detonation Safety

Underwater detonation training takes place in designated areas that are located away from popular recreational dive sites, primarily for human safety. Recreational dive sites often include shallow-water coral reefs, artificial reefs, and wrecks. Because these areas are avoided, this standard operating procedure could reduce impacts to environmental resources (e.g., shallow-water coral reefs, artificial reefs, and the biological resources such as fish that inhabit, shelter in, or feed among them) by reducing the potential for interaction with underwater detonation activities.

3.6.2 Mitigation Measures[4]

The Navy proposed to implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors from training and testing activities on ESA-listed marine mammals, sea turtles, fish, and coral. These mitigation measures fall into two categories: procedural mitigation and mitigation areas. Procedural mitigation is mitigation that the Navy will implement whenever and wherever an applicable training or testing activity takes place within the action area. Mitigation areas are geographic locations in the action area where the Navy will implement additional measures during all or a part of the year. Additional detail on both proposed procedural mitigation and mitigation areas is provided in the sections below.

The following sections summarize the mitigation measures that the Navy proposes to implement in association with the training and testing activities analyzed in this document. A complete discussion of the mitigation measures, as well as measures considered by the Navy but not proposed, and the evaluation process used by the Navy to develop, assess, and select mitigation measures, can be found the Navy's Final SEIS for this action (Navy 2019d). For each of the mitigation measures described below, the Navy operational community provided input on the practicability of each measure and whether additional mitigation could be implemented to further reduce potential impacts to ESA-listed species.

Procedural Mitigation

Procedural mitigation is mitigation that the Navy will implement whenever and wherever training or testing activities involving applicable acoustic, explosive, and physical disturbance and strike stressors take place within the action area. The Navy customized procedural mitigation for the activity categories and stressors applicable to the Proposed Action. Procedural mitigation generally involves: (1) the use of one or more trained Lookouts to observe for specific biological resources within a mitigation zone; (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate watch station for information

[4] We consider these mitigation measures "conservation measures", defined as actions that will be taken by the Navy and serve to minimize project effects on the ESA-listed species and designated critical habitat under review. As such we evaluate the effects of these measures as integral parts of the proposed action to be implemented by the Navy.

dissemination; and (3) requirements for the watch station to implement mitigation (e.g., halt an activity) until certain recommencement conditions have been met.

Lookouts are personnel who perform similar duties as the standard watch personnel described previously, such as observing for objects that could present a potential danger to the observation platform (e.g., debris in the water, incoming vessels, incoming aircraft). Lookouts have an additional duty of helping meet the Navy's mitigation requirements by visually observing for marine mammals and sea turtles. However, for some activities, Lookouts may also be required to observe for additional biological resources, such as birds, fish, or jellyfish aggregations. Some biological resources can be indicators of potential marine mammal or sea turtle presence because animals have been known to seek shelter in, feed on, or feed in them. The Navy proposes to observe for these additional biological resources during certain activities to protect ESA-listed species or to offer an additional layer of protection for marine mammals and sea turtles.

Mitigation zones are areas at the surface of the water within which applicable training or testing activities will be ceased, powered down, or modified to protect specific ESA-listed species from an auditory injury or impairment (PTS and TTS, respectively), non-auditory injury (from impulsive sources), or direct strike (e.g., vessel strike) to the maximum extent practicable. Mitigation zones are measured as the radius from a stressor. Implementation of procedural mitigation is most effective when mitigation zones are appropriately sized to be realistically observed during typical training and testing activity conditions. The Navy customized its mitigation zone sizes and mitigation requirements for each applicable training and testing activity category or stressor. The Navy developed each mitigation zone to be the largest area that (1) Lookouts can reasonably be expected to observe and detect animals during typical activity conditions (i.e., most environmentally protective), and (2) the Navy can commit to implementing mitigation without impacting safety, sustainability, or the ability to meet mission requirements.

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

The Navy's passive acoustic devices (e.g., remote acoustic sensors, expendable sonobuoys, passive acoustic sensors on submarines) can complement visual observations when passive acoustic assets are already participating in an activity. When in use, the passive acoustic assets can detect vocalizing marine mammals within the frequency bands already being monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot be used to determine an animal's location or confirm its presence

in a mitigation zone. Marine mammal detections made with the use of passive acoustic devices will be communicated to Lookouts to alert them of possible marine mammal presence in the vicinity. Lookouts will use any information on possible presence of animals from passive acoustic monitoring to assist in their visual observations of the mitigation zone.

The Navy takes several courses of action in response to a sighting of an applicable biological resource (e.g., ESA-listed species) in a mitigation zone. For sightings of marine mammals and sea turtles during an activity, the activity will be suspended or otherwise altered based on the applicable mitigation measures until one of the five recommencement conditions listed below has been met. The recommencement conditions are designed to allow a sighted animal to leave the mitigation zone before an activity or the use of a stressor resumes.

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

In some instances, such as if an animal dives underwater after a sighting, it may not be possible for a Lookout to visually verify if that animal has left the mitigation zone. To account for this, one of the recommencement conditions is an established post-sighting wait period. Wait periods are designed to allow animals time to resurface and be available to be sighted again before an activity or the use of a stressor resumes. The Navy proposes a 30 minute wait period to activities conducted from vessels and activities that involve aircraft that are not typically fuel constrained (e.g., maritime patrol aircraft). Thirty minutes is the maximum amount of time that those activities can be halted without preventing the activity from meeting its intended objective (Navy 2018b). A 30 minute period covers the average dive times of most marine mammals, and a portion of the dive times of sea turtles and deep-diving marine mammals (i.e., sperm whales, dwarf and pygmy sperm whales [*Kogia* species], and beaked whales). The Navy proposes a shorter wait period of ten minutes for activities that involve aircraft with fuel constraints (e.g., rotary-wing aircraft [i.e., helicopters], fighter aircraft), since ten minutes is the maximum amount of time that those activities can be halted without compromising safety due to aircraft fuel restrictions (Navy 2018b). A ten minute period covers a portion of the marine mammal and sea turtle dive times, but not the average dive times of all species.

The first procedural mitigation (Environmental Awareness and Education) is designed to aid Lookouts and other personnel with their observation and environmental compliance

responsibilities, as well as training and testing activity reporting requirements. The remainder of the procedural mitigation measures are organized by stressor type and activity category. For sonar and explosive sources, proposed mitigation is dependent on the sonar source and the NEW of the detonation.

Environmental Awareness and Education

The Navy provides environmental awareness and education training to aid in visual observation, environmental compliance, and reporting responsibilities. This training helps Navy personnel gain a better understanding of their personal environmental compliance roles and responsibilities and helps to ensure Navy-wide compliance with environmental requirements. The Navy will continue to provide environmental awareness and education training modules to the appropriate personnel as outlined in Table 26.

Table 26. Environmental awareness and education.

Procedural Mitigation Description
Stressor or Activity • All training and testing activities, as applicable
Resource Protection Focus • Marine mammals • Sea turtles
Mitigation Requirements • Appropriate personnel (including civilian personnel) involved in mitigation and training or testing activity reporting under the Proposed Action will complete one or more modules of the U.S. Navy Afloat Environmental Compliance Training Series, as identified in their career path training plan. Modules include the following: o **Introduction to the U.S. Navy Afloat Environmental Compliance Training Series.** The introductory module provides information on environmental laws (e.g., ESA, MMPA) and the corresponding responsibilities that are relevant to Navy training and testing activities. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship. o **Marine Species Awareness Training.** All bridge watch personnel, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare and mine warfare rotary-wing aircrews, Lookouts, and equivalent civilian personnel must successfully complete the Marine Species Awareness Training prior to standing watch or serving as a Lookout. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures. Navy biologists developed Marine Species Awareness Training to improve the effectiveness of visual observations for biological resources, focusing on marine mammals and sea turtles, and including jellyfish aggregations and flocks of seabirds. o **U.S. Navy Protective Measures Assessment Protocol.** This module provides the necessary instruction for accessing mitigation requirements during the event planning phase using the Protective Measures Assessment Protocol software tool. o **U.S. Navy Sonar Positional Reporting System and Marine Mammal Incident Reporting.** This module provides instruction on the procedures and activity reporting requirements for the Sonar Positional Reporting System and marine mammal incident reporting.

Active Sonar

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from active sonar, as outlined in Table 27. For low-frequency active sonar at 200 dB re 1 μPa rms or more and hull-mounted mid-frequency active sonar, bin MF1 has the longest predicted ranges to PTS. For low-frequency active sonar below 200 dB re 1 μPa rms, mid-frequency active sonar sources that are not hull-mounted, and high-

frequency active sonar, bin HF4 has the longest predicted ranges to PTS. For the highest source levels in bin MF1 and HF4, the mitigation zones extend beyond the respective average ranges to PTS for marine mammals. The mitigation zones for active sonar will help avoid or reduce the potential for exposure to PTS for marine mammals. The active sonar mitigation zones also extend into a portion of the average ranges to TTS for marine mammals; therefore, mitigation will help avoid or reduce the potential for some exposure to higher levels of TTS. Active sonar sources that fall within lower source bins or are used at lower source levels have shorter impact ranges than those discussed above; therefore, the mitigation zones will extend further beyond or into the average ranges to PTS and TTS for these sources.

Due to sea turtle hearing capabilities, the mitigation only applies to sea turtles during the use of sources below two kilohertz (kHz). The range to auditory effects for most active sonar sources in sea turtle hearing range (e.g., LF4) is zero meters. Impact ranges are longer (i.e., up to tens of meters) for active sonars with higher source levels. The mitigation zones for active sonar extend beyond the ranges to PTS and TTS for sea turtles; therefore, mitigation will help avoid or reduce the potential for exposure to these effects for sea turtles.

Table 27. Procedural mitigation for active sonar.

Procedural Mitigation Description

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

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

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

Mitigation Requirements

- Mitigation zones:
  - 1,000 yard (yd) power down, 500 yd power down, and 200 yd shut down for low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar
  - 200 yd shut down for low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar
- Prior to the initial start of the activity (e.g., when maneuvering on station):
  - Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of active sonar transmission.
- During the activity:
  - Low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); power down active sonar transmission by six dB if observed within 1,000 yd of the sonar source; power down an additional four dB (ten dB total) within 500 yd; cease transmission within 200 yd
  - Low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); cease active sonar transmission if observed within 200 yd of the sonar source.
- Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  - The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing or powering up active sonar transmission) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonar source; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-deployed sonar sources or 30 min. for vessel-deployed sonar sources; (4) for mobile activities, the active sonar source has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting; or (5) for activities using hull-mounted sonar, the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave, and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal sightings within the mitigation zone).

Weapons Firing Noise

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from weapons firing noise, as outlined in Table 28. The mitigation zone extends beyond the distance to which marine mammals and sea turtles would likely experience PTS or TTS from weapons firing noise; therefore, mitigation will help avoid or reduce the potential for exposure to these impacts.

Table 28. Procedural mitigation for weapons firing noise.

Procedural Mitigation Description
Stressor or Activity • Weapons firing noise associated with large-caliber gunnery activities
Resource Protection Focus • Marine mammals • Sea turtles

Number of Lookouts and Observation Platform
• 1 Lookout positioned on the ship conducting the firing
  o Depending on the activity, the Lookout could be the same one described in Table 31 for Explosive Medium-Caliber and Large-Caliber Projectiles or in
  o Table 40 for Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions

Mitigation Requirements

- Mitigation zone:
  - 30° on either side of the firing line out to 70 yd from the muzzle of the weapon being fired
- Prior to the initial start of the activity:
  - Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of weapons firing.
- During the activity:
  - Observe the mitigation zone for marine mammals and sea turtles; if observed, cease weapons firing.
- Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  - The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing weapons firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the firing ship; (3) the mitigation zone has been clear from any additional sightings for 30 min.; or (4) for mobile activities, the firing ship has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

Explosive Sonobuoys

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive sonobuoys, as outlined in Table 29. In the NMFS MITT 2017 biological opinion, explosive sonobuoys had two mitigation zone sizes based on NEW and the associated average ranges to PTS. When developing mitigation for the Proposed Action, the Navy analyzed the potential for increasing the size of these mitigation zones. The Navy identified an opportunity to increase the mitigation zone size by 250 yards (yd) for sonobuoys using up to 2.5-pound (lb.) NEW so that explosive sonobuoys will implement a 600-yd mitigation zone, regardless of NEW, to enhance protections to the maximum extent practicable.

Table 29. Procedural mitigation for explosive sonobuoys.

Procedural Mitigation Description
Stressor or Activity • Explosive sonobuoys
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft or on a small boat • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.

Mitigation Requirements

- Mitigation zone:
  - 600 yd around an explosive sonobuoy
- Prior to the initial start of the activity (e.g., during deployment of a sonobuoy pattern, which typically lasts 20–30 min.):
  - Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations.
  - Visually observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of sonobuoy or source/receiver pair detonations.
- During the activity:
  - Observe the mitigation zone for marine mammals and sea turtles; if observed, cease sonobuoy or source/receiver pair detonations.
- Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  - The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonobuoy; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained.
- After completion of the activity (e.g., prior to maneuvering off station):
  - When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures.
  - If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of the activity. In accordance with the NMFS MITT 2017 biological opinion consultation requirements, the Navy currently conducts post-activity observations for some, but not all explosive activities. When developing mitigation for the Proposed Action, the Navy determined that it could expand this requirement to other explosive activities for enhanced consistency and to help determine if any resources were injured during explosive events, when practical. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. There are typically multiple platforms in the vicinity of activities that use explosive sonobuoys (e.g., safety aircraft). When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting an ESA-listed species.

Some activities that use explosive sonobuoys involve detonations of a single sonobuoy or sonobuoy pair, while other activities involve deployment of multiple sonobuoys that may be dispersed in a pattern over a large distance. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing the mitigation zone around a single sonobuoy or sonobuoy pair than when observing multiple sonobuoys dispersed over a large distance. When observing large distances, Lookouts will be more likely to detect large visual cues (e.g., whale blows, breaching whales, or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles.

Bin E3 has the longest predicted impact ranges for explosive sonobuoys used in the action area (e.g., MK-61 Signal Underwater Sound sonobuoys). For the largest explosive in bin E3, the mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the average ranges to PTS for sea turtles and mid-frequency cetaceans, and into a portion of the average ranges to PTS for low-frequency cetaceans. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and TTS for the largest explosives in bin E3. Smaller explosives in bin E3 and explosives in smaller source bins (E1) have shorter predicted impact ranges; therefore, the mitigation zone will extend further beyond or cover a greater portion of the impact ranges for these explosives.

Explosive Torpedoes

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive torpedoes, as outlined in Table 30. The post-activity observations for explosive torpedoes will help the Navy determine if any resources were injured during the activity. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. Typically, when aircraft are firing explosive torpedoes, there are additional observation aircraft, support vessels (e.g., range craft for torpedo retrieval), or other safety aircraft in the vicinity. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources. Explosive torpedo activities involve detonations at a target located down range of the firing platform. Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting large visual cues (e.g., whale blows, breaching whales, or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles.

Bin E11 has the longest predicted impact ranges for explosive torpedoes used in the action area. For the largest explosive in bin E11, the mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the average ranges to PTS for sea turtles, low-frequency cetaceans, and mid-frequency cetaceans. The mitigation zone extends beyond the average range to TTS for sea turtles and mid- frequency cetaceans, and into a portion of the average ranges to TTS for low-frequency cetaceans. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E11. Explosive torpedoes in smaller source bins (e.g., E8) have shorter predicted impact ranges; therefore, the mitigation zone will extend further beyond or cover a greater portion of the impact ranges for these explosives.

Table 30. Procedural mitigation for explosive torpedoes.

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

Explosive Medium-Caliber and Large-Caliber Projectiles

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive gunnery activities, as outlined in Table 31. In the NMFS MITT 2017 biological opinion, explosive gunnery activity mitigation zones were based on NEW and the associated average ranges to PTS. When developing mitigation for the Proposed Action, the Navy analyzed the potential for increasing the size of these mitigation zones. The Navy identified an opportunity to increase the mitigation zone size by 400 yds for surface-to-surface activities to enhance protections to the maximum extent practicable.

The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of the activity. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during,

and after the activity while performing their regular duties. Typically, when aircraft are firing explosive munitions there are additional observation aircraft, multiple aircraft firing munitions, or other safety aircraft in the vicinity. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources.

Large-caliber gunnery activities involve vessels firing projectiles at targets located up to six nautical miles down range. Medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets located up to 4,000 yd down range, although typically much closer. As described in Section 5.2.1 (At-Sea Procedural Mitigation Development) of the Navy's 2019 Final Supplemental EIS/OEIS (Navy 2019d), certain platforms, such as the small boats and aircraft used during explosive medium-caliber gunnery exercises, have manning or space restrictions; therefore, the Lookout for these activities is typically an existing member of the aircraft or boat crew who is responsible for other essential tasks (e.g., navigation). Due to their relatively lower vantage point, Lookouts on vessels (during medium-caliber or large-caliber gunnery exercises) will be more likely to detect large visual cues (e.g., whale blows, breaching whales, or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles when observing around targets located at the furthest firing distances. The Navy will implement larger mitigation zones for large-caliber gunnery activities than for medium-caliber gunnery activities due to the nature of how the activities are conducted. For example, large-caliber gunnery activities are conducted from surface combatants, so Lookouts can observe a larger mitigation zone because they typically have access to high-powered binoculars mounted on the ship deck. This will enable observation of the distant mitigation zone in combination with hand-held binoculars and naked-eye scanning. Lookouts in aircraft (during medium-caliber gunnery exercises), have a relatively higher vantage point for observing the mitigation zones but will still be more likely to detect individual marine mammals and sea turtles when observing mitigation zones located close to the firing platform than at the furthest firing distances.

Bin E5 (e.g., 5-inch [in.] projectiles) has the longest predicted impact ranges for explosive projectiles that apply to the 1,000-yd mitigation zone. Bin E2 (e.g., 40-mm projectiles) has the longest predicted impact ranges for explosive projectiles that apply to the 600-yd and 200-yd mitigation zones. The 1,000-yd, 600-yd, and 200-yd mitigation zones extend beyond the respective ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The 1,000-yd, 600-yd, and 200-yd mitigation zones extend beyond the respective average ranges to PTS for sea turtles, mid-frequency cetaceans, and low-frequency cetaceans. The mitigation zones also extend beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E5 and bin E2. Explosives in smaller source bins (e.g., E1) have shorter predicted impact ranges; therefore, the mitigation zones will extend further beyond or cover a greater portion of the impact ranges for these explosives.

Table 31. Procedural mitigation for explosive medium-caliber and large-caliber projectiles.

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using explosive medium-caliber and large-caliber projectiles   o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout on the vessel or aircraft conducting the activity   o For activities using explosive large-caliber projectiles, depending on the activity, the Lookout could be the same as the one described in Table 28 for Weapons Firing Noise • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.

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

Explosive Missiles and Rockets

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive missiles and rockets, as outlined in Table 32. In the NMFS MITT 2017 biological opinion, explosive missile and rocket mitigation zones were based on NEW and the associated average ranges to PTS. When developing the mitigation for the Proposed Action, the Navy analyzed the potential for increasing the mitigation zone sizes.

The Navy identified an opportunity to increase the mitigation zone by 1,100 yd for missiles and rockets using 21–500 lb. NEW to enhance protections to the maximum extent practicable.

Table 32. Procedural mitigation for explosive missiles and rockets.

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

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

The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of the activity. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. Typically, when aircraft are firing explosive munitions there are additional observation aircraft, multiple aircraft firing munitions, or other safety aircraft in the vicinity. For example, during typical explosive missile exercises, two aircraft circle the activity location. One aircraft clears the intended impact location while the other fires, and vice versa. A third aircraft is typically present for safety or proficiency inspections. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources.

Missile and rocket exercises involve firing munitions at a target typically located up to 15 NM down range, and infrequently up to 75 NM down range. Due to the distance between the mitigation zone and the observation platform, the Lookout will have a better likelihood of detecting marine mammals and sea turtles during close-range observations and are less likely to detect these resources once positioned at the firing location, particularly individual marine mammals, cryptic marine mammal species, and sea turtles. There is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its firing position). The Navy will implement larger mitigation zones for missiles using 21–500 lb. NEW than for missiles and rockets using 0.6–20 lb. NEW due to the nature of how these activities are conducted. During activities using missiles in the larger NEW category, firing aircraft (e.g., maritime patrol aircraft) have the capability of mitigating a larger area due to their larger fuel capacity. During activities using missiles or rockets in the smaller NEW category, firing aircraft (e.g., rotary-wing aircraft) are typically constrained by their fuel capacity. The mitigation applies to aircraft-deployed missiles and rockets because aircraft can fly over the intended impact area prior to commencing firing. Mitigation would be ineffective for vessel-deployed missiles and rockets because of the inability for a Lookout to detect marine mammals or sea turtles from a vessel from the distant firing position.

Bin E10 (e.g., Harpoon missiles) has the longest predicted impact ranges for explosive missiles that apply to the 2,000-yd mitigation zone. Bin E6 (e.g., Hellfire missiles) has the longest predicted impact ranges for explosive missiles and rockets that apply to the 900-yd mitigation zone. The 2,000-yd and 900-yd mitigation zones extend beyond the respective ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zones extend beyond the respective average ranges to PTS for sea turtles, mid-frequency cetaceans, and low-frequency cetaceans. The mitigation zones also extend beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E10 and bin E6. Explosives in smaller source bins (e.g., missiles in bin E8, rockets in bin E3) have shorter predicted impact ranges; therefore, the mitigation zones will cover a greater portion of the impact ranges for these explosives.

Explosive Bombs

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive bombs, as outlined in Table 33. The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of this activity. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. Typically, when aircraft are firing explosive munitions there are additional observation aircraft, multiple aircraft firing munitions, or other

safety aircraft in the vicinity. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources.

Bombing exercises involve an aircraft deploying munitions at a surface target located beneath the firing platform. During target approach, aircraft maintain a relatively steady altitude of approximately 1,500 ft. Lookouts, by necessity for safety and mission success, primarily focus their attention on the water surface surrounding the intended detonation location (i.e., the mitigation zone). Being positioned in an aircraft gives the Lookout a good vantage point for observing marine mammals and sea turtles throughout the mitigation zone.

Bin E12 (e.g., 2,000-lb. bombs) has the longest predicted impact ranges for explosive bombs used in the action area. The 2,500-yd mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the average ranges to PTS for sea turtles, mid-frequency cetaceans, and low-frequency cetaceans. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest bombs in bin E12. Smaller bombs (e.g., 250-lb. bombs, 500-lb. bombs) have shorter predicted impact ranges; therefore, the mitigation zone will extend further beyond or cover a greater portion of the impact ranges for these explosives.

Table 33. Procedural mitigation for explosive bombs.

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in the aircraft conducting the activity • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.

Mitigation Requirements

- Mitigation zone:
  - 2,500 yd around the intended target
- Prior to the initial start of the activity (e.g., when arriving on station):
  - Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment.
- During the activity (e.g., during target approach):
  - Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment.
- Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  - The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target; (3) the mitigation zone has been clear from any additional sightings for 10 min.; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.
- After completion of the activity (e.g., prior to maneuvering off station):
  - When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures.
  - If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Sinking Exercises

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from sinking exercises, as outlined in Table 34. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. Sinking exercises typically involved multiple participating platforms. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources. The two-hour post-activity observations for sinking exercises are a continuation from the NMFS MITT 2017 biological opinion and will help the Navy determine if any resources were injured during the activity. Sinking exercises are scheduled to ensure they are conducted only in daylight hours. The Navy will be able to complete the full two hours of post-activity observation during typical activity conditions and it is unlikely that observations will be shortened due to nightfall.

There is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its distant firing position). The Lookout positioned on the vessel will have a higher likelihood of detecting individual marine mammals and sea turtles that are in the central portion of the mitigation zone near the target ship hulk. Near the perimeter of the mitigation zone, the Lookout will be more likely to detect large visual cues (e.g., whale blows, breaching whales, or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. The Lookout positioned in the aircraft will be able to assist the vessel-based Lookout by observing the entire mitigation zone, including near the perimeter, because the aircraft will be able to transit a larger area more quickly (e.g., during range clearance), and will offer a better

vantage point. Some species of sea turtles forage on jellyfish in the region where this activity occurs. The Lookouts will also observe for jellyfish aggregations, which will further help avoid or reduce potential impacts on sea turtles within the mitigation zone.

Table 34. Procedural mitigation for sinking exercises.

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

Bin E12 has the longest predicted impact ranges for the types of explosives used during sinking exercises in the action area. For the largest explosive in bin E12, the mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the average ranges to PTS for sea turtles and marine mammals. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E12. Smaller

explosives in bin E12 and explosives in smaller source bins (e.g., E10, E5) have shorter predicted impact ranges; therefore, the mitigation zone will extend further beyond or cover a greater portion of the impact ranges for these explosives.

Explosive Mine Countermeasure and Neutralization Activities

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive mine countermeasure and neutralization activities, as outlined in Table 35. The mitigation applies to all explosive mine countermeasure and neutralization activities except those that involve the use of Navy divers, which are discussed further below.

Table 35. Procedural mitigation for explosive mine countermeasure and neutralization activities.

Procedural Mitigation Description
Stressor or Activity • Explosive mine countermeasure and neutralization activities
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on a vessel or in an aircraft • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.

Mitigation Requirements
• Mitigation zone:
  o 600 yd around the detonation site
• Prior to the initial start of the activity (e.g., when maneuvering on station; typically, 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained):
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of detonations.
• During the activity:
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease detonations.
• Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to detonation site; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained.
• After completion of the activity (typically 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained):
  o Observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures.
  o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

The types of charges used in these activities are positively controlled, which means the detonation is controlled by the personnel conducting the activity and is not authorized until the mitigation zone is clear at the time of detonation. The post-activity observations are a continuation from the NMFS MITT 2017 biological opinion and will help the Navy determine if any resources were injured during the activity. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources. The small observation area and proximity to the observation platform will result in a high likelihood that the Lookout will be able to detect marine mammals and sea turtles throughout the mitigation zone (regardless of the type of observation platform used).

Bin E4 (e.g., 5-lb. NEW charges) has the longest predicted impact ranges for explosives used in the action area during mine countermeasures and neutralization activities. The 600-yd mitigation zone extends beyond the respective ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the respective average ranges to PTS for sea turtles, mid-frequency cetaceans, and low-frequency cetaceans. The mitigation zones also extend beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E4. Smaller explosives within bin E4 have shorter predicted impact ranges; therefore, the mitigation zones will cover a greater portion of the impact ranges for these explosives.

Explosive Mine Neutralization Activities Involving Navy Divers

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals, sea turtles, and scalloped hammerhead sharks from explosive mine neutralization activities involving Navy divers (Table 36). New for Phase III, the Navy has proposed to add giant manta rays to this procedural mitigation measure. In the NMFS MITT 2017 biological opinion, the mitigation zones for explosive mine neutralization activities involving Navy divers were based on NEW and the associated average ranges to PTS. When developing the mitigation for the Proposed Action, the Navy analyzed the potential for increasing the size of the mitigation zones. The Navy identified an opportunity to increase the mitigation zone size for positive control charges in bin E4 or below to enhance protections to the maximum extent practicable and for consistency across activities. The post-activity observations are a continuation from the 2017 opinion and will help the Navy determine if any resources were injured during the activity. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources.

The charges used during explosive mine neutralization activities involving Navy divers are either positively controlled or initiated using a time-delay fuse. Positive control means the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation. Time-delay means the detonation is fused with a specified time-delay by the personnel conducting the activity and is not authorized until the area is clear at the time the fuse is initiated but cannot be terminated once the fuse is initiated due to human safety concerns. For activities using a time-delay fuse (which have a maximum charge size of 20-lb. NEW), there is a remote chance that animals could swim into the mitigation zone after the fuse has been initiated. The Navy established a mitigation measure to set time-delay firing devices not to exceed 10 minutes to limit the potential time that animals have to swim into the mitigation zone after fuse initiation. During activities under positive control, the Navy can cease detonations at any time in response to a sighting of an ESA-listed species. For these reasons, all activities using a time-delay fuse will implement the 1,000-yd mitigation zone, while activities that are under positive control will implement the 500-yd mitigation zone.

Table 36. Procedural mitigation for explosive mine neutralization activities involving Navy divers.

Procedural Mitigation Description
Stressor or Activity • Explosive mine neutralization activities involving Navy divers
Resource Protection Focus • Marine mammals • Sea turtles • Fish (hammerhead sharks and manta rays of any species due to the difficulty of differentiating species)
Number of Lookouts and Observation Platform • 2 Lookouts (two small boats with one Lookout each, or one Lookout on a small boat and one in a rotary-wing aircraft) when implementing the smaller mitigation zone • 4 Lookouts (two small boats with two Lookouts each), and a pilot or member of an aircrew will serve as an additional Lookout if aircraft are used during the activity, when implementing the larger mitigation zone • All divers placing the charges on mines will support the Lookouts while performing their regular duties and will report applicable sightings to their supporting small boat or Range Safety Officer. • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zones: – For Lookouts on small boats or aircraft: 500 yds around the detonation site during activities under positive control – For Lookouts on small boats or aircraft: 1,000 yds around the detonation site during activities using time-delay fuses – For divers: The underwater detonation location, which is defined as the sea space within the divers' range of visibility but no further than the mitigation zone specified for Lookouts on small boats or aircraft (500 yds or 1,000 yds depending on the charge type) • Prior to the initial start of the activity (e.g., when maneuvering on station for activities under positive control; 30 minutes for activities using time-delay firing devices): – Lookouts on small boats or aircraft will observe the mitigation zone for marine mammals, sea turtles, hammerhead sharks, and manta rays; if observed, the Navy will relocate or delay the start of detonations or fuse initiation. • During the activity: – Lookouts on small boats or aircraft will observe the mitigation zone for marine mammals, sea turtles, hammerhead sharks, and manta rays; if observed, the Navy will cease detonations or fuse initiation.

Procedural Mitigation Description
– While performing their normal duties, divers will observe the underwater detonation location for marine mammals, sea turtles, hammerhead sharks, and manta rays. Divers will notify their supporting small boat or Range Safety Officer of marine mammal, sea turtle, hammerhead shark, and manta ray sightings at the underwater detonation location; if observed, the Navy will cease detonations or fuse initiation. – To the maximum extent practicable depending on mission requirements, safety, and environmental conditions, boats will position themselves near the mid-point of the mitigation zone radius (but outside of the detonation plume and human safety zone), will position themselves on opposite sides of the detonation location (when two boats are used), and will travel in a circular pattern around the detonation location with one Lookout observing inward toward the detonation site and the other observing outward toward the perimeter of the mitigation zone. – If used, aircraft will travel in a circular pattern around the detonation location to the maximum extent practicable. – The Navy will not set time-delay firing devices to exceed ten minutes. • Commencement/recommencement conditions after a marine mammal, sea turtle, hammerhead shark, or manta ray sighting before or during the activity: – The Navy will allow a sighted marine mammal, sea turtle, hammerhead shark, or manta ray to leave the underwater detonation location or mitigation zone (as applicable) prior to the initial start of the activity (by delaying the start) or during the activity (by not commencing detonations or fuse initiation) until one of the following conditions has been met: (1) the animal is observed exiting the 500 yd or 1,000 yd mitigation zone; (2) the animal is thought to have exited the 500 yd or 1,000 yd mitigation zone based on a determination of its course, speed, and movement relative to the detonation site; or (3) the 500 yd or 1,000 yd mitigation zones (for Lookouts on small boats or aircraft), and the underwater detonation location (for divers) have been clear from any additional sightings for ten minutes during activities under positive control with aircraft that have fuel constraints, or 30 minutes during activities under positive control with aircraft that are not typically fuel constrained and during activities using time-delay firing devices. • After completion of an activity (for 30 minutes): – Observe the vicinity of where detonations occurred; if any injured or dead marine mammals, sea turtles, hammerhead sharks, or manta rays are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Bin E6 (e.g., 20-lb. NEW) has the longest predicted impact ranges for the time-delay explosives that apply to the 1,000-yd mitigation zone. Bin E6 also has the longest predicted impact ranges for the positive control explosives that apply to the 500-yd mitigation zone. The 1,000-yd and 500-yd mitigation zones extend beyond the respective ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. For time-delay charges, the 1,000-yd mitigation zone extends beyond the average ranges to PTS for sea turtles, mid-frequency cetaceans, and low-frequency cetaceans. For positive control charges, the 500-yd mitigation zone extends beyond the average ranges to PTS for sea turtles and mid-frequency cetaceans, and into a portion of the average ranges to PTS for low-frequency cetaceans. The mitigation zones also extend beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E6. Smaller explosives within bin E6 and explosives in smaller source bins (e.g., E5) have shorter predicted impact ranges; therefore, the mitigation zones will cover a greater portion of the impact ranges for these explosives.

Maritime Security Operations – Anti-Swimmer Grenades

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from anti-swimmer grenades during Maritime Security

Operations, as outlined in Table 37. The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of the activity. The Navy is adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources. The small mitigation zone size and proximity to the observation platform result in a high likelihood that Lookouts will be able to detect marine mammals and sea turtles throughout the mitigation zone.

Explosives used during Maritime Security Operations – Anti-Swimmer Grenades exercises are in bin E2 (e.g., 0.5-lb. NEW). The mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the average ranges to PTS for sea turtles, mid-frequency cetaceans, and low-frequency cetaceans. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E2.

Table 37.Procedural Mitigation for Maritime Security Operations – Anti-Swimmer Grenades

Procedural Mitigation Description
Stressor or Activity • Maritime Security Operations – Anti-Swimmer Grenades
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the small boat conducting the activity • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties. **Mitigation Requirements** • Mitigation zone: o 200 yd around the intended detonation location • Prior to the initial start of the activity (e.g., when maneuvering on station): o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of detonations. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended detonation location; (3) the mitigation zone has been clear from any additional sightings for 30 min.; or (4) the intended detonation location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

- After completion of the activity (e.g., prior to maneuvering off station):
  - When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures.
  - If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Vessel Movement

The Navy will implement procedural mitigation to avoid or reduce the potential for vessel strikes of marine mammals and sea turtles, as outlined in Table 38. Although the Navy is unable to position Lookouts on unmanned vessels, as a standard operating procedure, some vessels that operate autonomously have embedded sensors that aid in avoidance of large objects. The embedded sensors may help those unmanned vessels avoid vessel strikes of marine mammals.

Table 38. Procedural mitigation for vessel movement.

Procedural Mitigation Description
Stressor or Activity • Vessel movement   o The mitigation will not be applied (1) if the vessel's safety is threatened, (2) if the vessel is restricted in its ability to maneuver (e.g., during launching and recovery of aircraft or landing craft, during towing activities, when mooring, etc.), 3) if the vessel is operated autonomously, or (4) when impractical based on mission requirements (e.g., during Amphibious Assault and Amphibious Raid exercises).
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout on the vessel that is underway

Mitigation Requirements
• Mitigation zones:
  o 500 yd around whales
  o 200 yd around other marine mammals (except bow-riding dolphins)
  o Within the vicinity of sea turtles
• During the activity:
  o When underway, observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance.
• Additional requirements:
  o Within the designated vessel traffic lane during Amphibious Assault and Amphibious Raid exercises, while underway, observe for sea turtles; if observed, cease beach approach. To allow a sighted sea turtle to leave the designated vessel traffic lanes, the Navy will not recommence the beach approach until one of the recommencement conditions has been met: (1) the animal is observed exiting the designated vessel traffic lane; (2) the animal is thought to have exited the designated vessel traffic lane based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the designated vessel traffic lane has been clear from any additional sightings for 30 min.
  o If a marine mammal or sea turtle vessel strike occurs, the Navy will follow the established incident reporting procedures.

Towed In-Water Devices

The Navy will continue to implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from towed in-water devices, as outlined in Table 39. The small mitigation zone size and proximity to the observation platform will result in a high

likelihood that Lookouts will be able to detect marine mammals throughout the mitigation zone when manned vessels or manned aircraft are towing in-water devices.

Table 39. Procedural mitigation for towed in-water devices.

Procedural Mitigation Description
Stressor or Activity • Towed in-water devices o Mitigation applies to devices that are towed from a manned surface platform or manned aircraft o The mitigation will not be applied if the safety of the towing platform or in-water device is threatened
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the manned towing platform
Mitigation Requirements • Mitigation zones: o 250 yd around marine mammals o Within the vicinity of sea turtles • During the activity (i.e., when towing an in-water device): o Observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance.

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

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from small-, medium-, and large-caliber non-explosive practice munitions, as outlined in

Table 40. The mitigation zone is conservatively designed to be several times larger than the impact footprint for large-caliber non-explosive practice munitions, which are the largest projectiles used for these activities. Small-caliber and medium-caliber non-explosive practice munitions have smaller impact footprints than large-caliber non-explosive practice munitions; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller projectiles.

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

Table 40. Procedural mitigation for small-, medium-, and large-caliber non-explosive practice munitions.

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using small-, medium-, and large-caliber non-explosive practice munitions   o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the platform conducting the activity   o Depending on the activity, the Lookout could be the same as the one described in Table 28 for Weapons Firing Noise

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

Non-Explosive Missiles and Rockets

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from non-explosive missiles and rockets, as outlined in Table 41. The mitigation zone for non-explosive missiles and rockets is conservatively designed to be several times larger than the impact footprint for the largest non-explosive missile used for these activities. Smaller non-explosive missiles and non-explosive rockets have smaller impact footprints than the largest non- explosive missile used for these activities; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller projectiles.

Mitigation applies to activities using non-explosive missiles or rockets fired from aircraft at targets that are typically located up to 15 NM down range, and infrequently up to 75 NM down range. There is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its firing position). Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting marine mammals and sea turtles during the close-range observations and are less likely to detect these resources once positioned at the firing location, particularly individual marine mammals, cryptic marine mammal species, and sea turtles.

Table 41. Procedural mitigation for non-explosive missiles and rockets.

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

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

Non-Explosive Bombs and Mine Shapes

The Navy will continue to implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from non-explosive bombs and mine shapes, as outlined in

Table 42. The mitigation zone for non-explosive bombs and mine shapes is conservatively designed to be several times larger than the impact footprint for the largest non-explosive bomb used for these activities. Smaller non-explosive bombs and mine shapes have smaller impact footprints than the largest non- explosive bomb used for these activities; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller military expended materials.

Activities involving non-explosive bombing and mine laying involve aircraft deploying munitions or mine shapes from a relatively steady altitude of approximately 1,500 ft. at a surface target or in an intended minefield located beneath the aircraft. Due to the mitigation zone size, proximity to the observation platform, and the good vantage point from an aircraft, Lookouts will be able to observe the entire mitigation zone during approach of the target or intended minefield location.

Table 42. Procedural mitigation for non-explosive bombs and mine shapes.

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

Mitigation Areas

In addition to procedural mitigation, the Navy will implement mitigation measures within specified areas to avoid potential impacts on marine mammals (including ESA-listed species) and seafloor resources (which serve valuable ecosystem functions and provide habitat for ESA-listed species and their prey). Mitigation areas are geographic locations in the action area where the Navy will implement additional avoidance and minimization measures during all or a part of the year (mitigation applies year-round unless specified otherwise). Should national security present a requirement to conduct activities that the Navy would otherwise prohibit in a particular mitigation area, naval units will obtain permission from the appropriate designated command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include information about the event in its annual activity reports to NMFS.

The Navy considered several factors when determining the location of proposed geographic mitigation areas. First, they evaluated whether the mitigation area would be effective in reducing impacts to resources of biological or ecological importance. Next, the Navy operational community assessed how and to what degree implementation of mitigation measures would be compatible with planning, scheduling, and conducting proposed training and testing activities. A more thorough discussion on the factors used by the Navy to determine which areas to propose for geographic mitigation is provided in the MITT FSEIS (Navy 2019d).

Mitigation Areas for Seafloor Resources

The Navy proposes to implement mitigation to avoid and minimize impacts to seafloor resources from explosives, physical disturbance, and strike stressors in mitigation areas throughout the Action Area (Table 43). Seafloor resource mitigation would help the Navy avoid or reduce impacts from explosives, physical disturbance, and strike stressors on seafloor resources, and consequently to any ESA-protected resources that inhabit, shelter, rest, feed, or occur in the mitigation areas. Figure 13 and Figure 14 show the relevant seafloor resources and the Navy training or testing locations that overlap them.

The Navy developed mitigation areas as either the anchor swing circle diameter or a 350-yd radius around a seafloor resource, as indicated by the best available georeferenced data. To facilitate mitigation implementation, the Navy will include maps of the best available georeferenced data for shallow-water coral reefs, artificial reefs, live hard bottom, and shipwrecks in its Protective Measures Assessment Protocol. Mitigation areas apply to georeferenced resources because the Navy requires accurate resource identification and mapping for the mitigation to be effective and practical to implement.

Mitigating within the anchor swing circle will protect seafloor resources during precision anchoring activities when factoring in environmental conditions that could affect anchoring position and swing circle size, such as winds, currents, and water depth. For other activities applicable to the mitigation, a 350-yd radius around a seafloor resource is a conservatively sized mitigation area that will provide protection well beyond the maximum expected impact footprint (e.g., crater and expelled material radius) of the explosives and non-explosive practice munitions used in the action area. The mitigation zone size extends beyond the military expended material with the largest footprint for all Navy Action Areas where this mitigation measure is implemented. For example, the military expended material with the largest footprint (which is not used in the MITT Action Area) is an explosive mine with a 650-lb. NEW, which has an estimated impact footprint of approximately 14,800 square ft. and an associated radius of 22.7 yd The largest explosive applicable to this mitigation in the MITT Study Area has a charge size of 20 lb. net explosive weight, which has an estimated impact footprint of 135 square ft. and an associated radius of 2.19 yd Therefore, the 350 yd mitigation area is well beyond the maximum expected direct impact footprint, and it further mitigates some level of indirect impact from explosive disturbances.

Table 43. Proposed mitigation areas for seafloor resources.

Summary of Mitigation Requirements
Mitigation Areas for Seafloor Resources
• **Within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks**: o The Navy will not conduct precision anchoring (except at designated anchorages and nearshore training areas around Guam and within Apra Harbor, where these resources will be avoided to the maximum extent practicable). • **Within a 350-yd radius of live hard bottom, artificial reefs, and shipwrecks:** o The Navy will not conduct explosive mine countermeasure and neutralization activities or explosive mine neutralization activities involving Navy divers (except at designated nearshore training areas, where these resources will be avoided to the maximum extent practicable). o The Navy will not place mine shapes, anchors, or mooring devices on the seafloor (except in designated locations, where these resources will be avoided to the maximum extent practicable). • **Within a 350 yd radius of shallow-water coral reefs:** o The Navy will not conduct explosive or non-explosive small-, medium-, and large-caliber gunnery activities using a surface target; explosive or non-explosive missile and rocket activities using a surface target; explosive or non- explosive bombing and mine-laying activities; explosive or non-explosive mine countermeasure and neutralization activities; and explosive or non-explosive mine neutralization activities involving Navy divers (except at designated nearshore training areas, where these resources will be avoided to the maximum extent practicable). o The Navy will not place mine shapes, anchors, or mooring devices on the seafloor (except in designated locations, where these resources will be avoided to the maximum extent practicable).

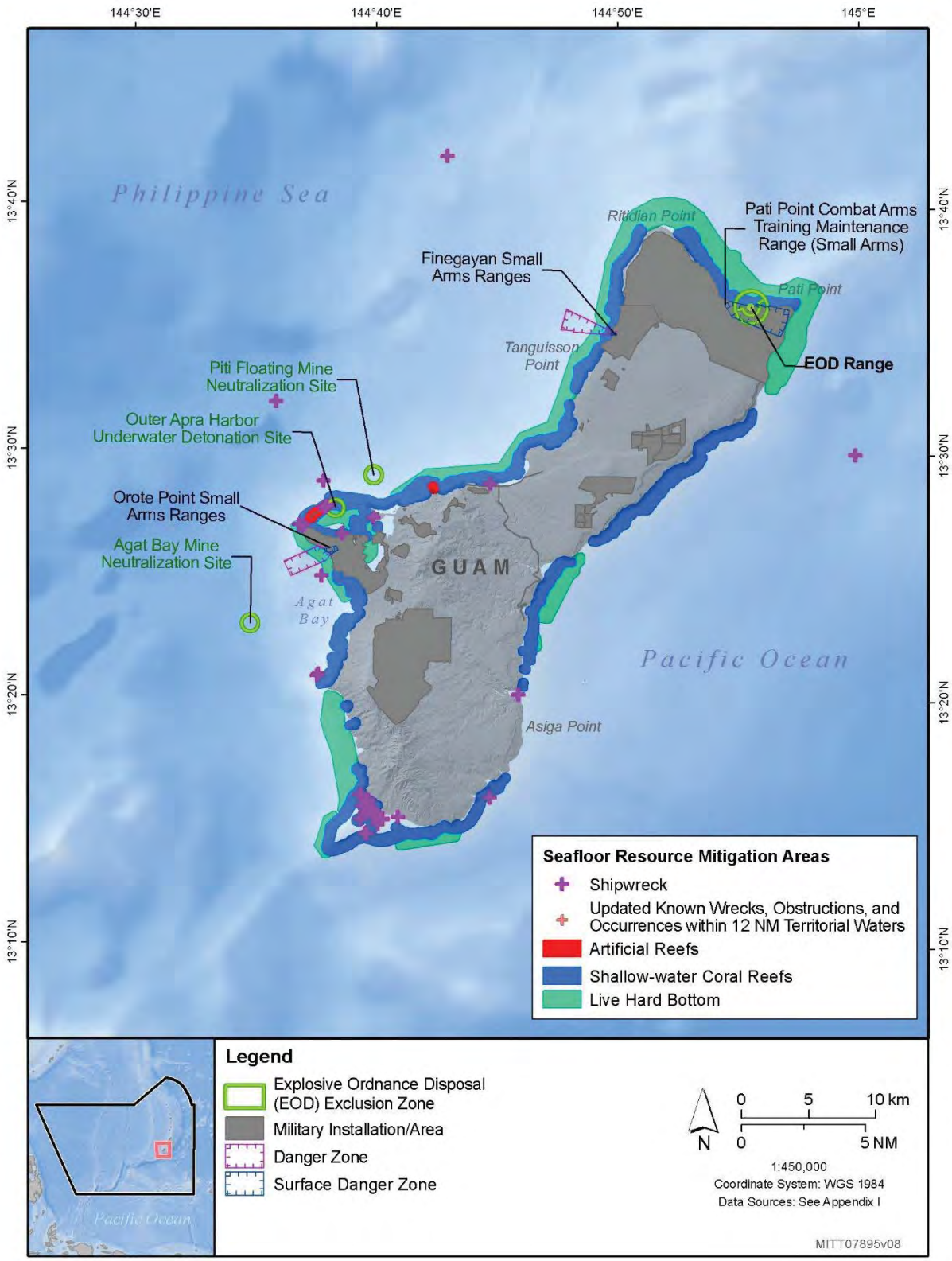


Figure 13. Seafloor resource mitigation areas off Guam.

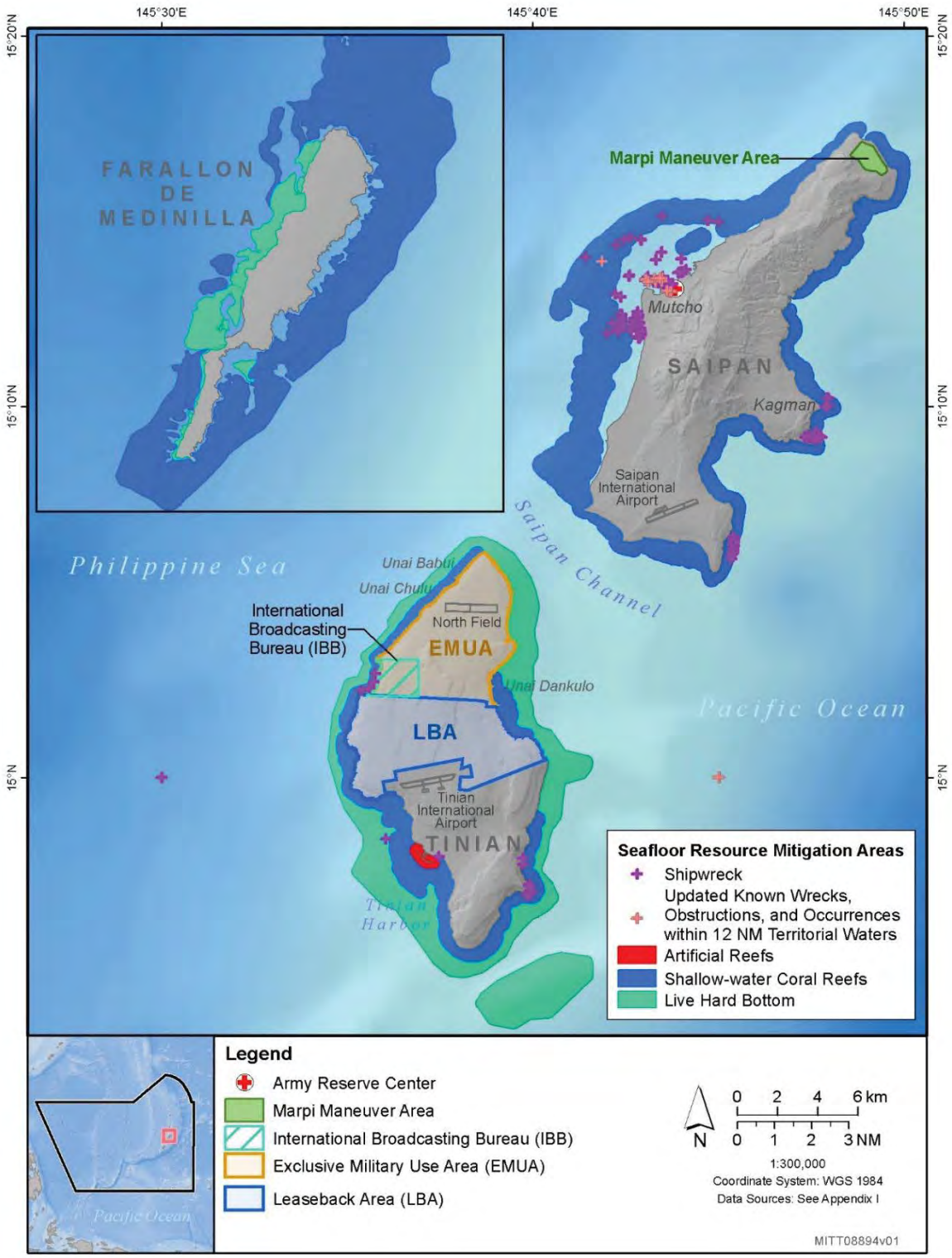


Figure 14. Seafloor resource mitigation areas off Tinian, Saipan, and Farallon de Medinilla.

Mitigation Areas for Marine Mammals and Sea Turtles

The Navy has proposed three new mitigation areas within the MITT Action Area to protect marine mammals and sea turtles: Marpi Reef, Chalan Kanoa Reef, and Agat Bay (Table 44). The Marpi Reef and Chalan Kanoa Reef Mitigation Areas are designed to avoid or reduce potential impacts from acoustic stressors on ESA-listed humpback whales in an area thought to be important for reproduction. Other biological resources have also been observed or are expected to be present at these reefs, including other species of marine mammals, sea turtles, invertebrates,

Table 44. Proposed mitigation areas for marine mammals and sea turtles.

Mitigation Area Description
Stressor or Activity • Surface Ship Hull-Mounted Mid-frequency Active Sonar (bin MF1) • In-water Explosives
Resource Protection Focus • Marine mammals • Sea turtles
Mitigation Requirements **Marpi Reef Mitigation Area and Chalan Kanoa Reef Mitigation Area[1]** – The Navy will conduct a maximum combined total of 20 hours of surface ship hull-mounted MF1 mid-frequency active sonar during training and testing from 1 December to 30 April within the Marpi Reef Mitigation Area and Chalan Kanoa Reef Mitigation Area. The Navy will report the total hours of active sonar (all bins, by bin) used in the Marpi Reef Mitigation Area and Chalan Kanoa Reef Mitigation Area from 1 December to 30 April in its annual training and testing activity reports submitted to NMFS. Should national security present a requirement to use surface ship hull-mounted MF1 mid-frequency active sonar between 1 December to 30 April, the Navy will provide NMFS with advance notification of the activity. – The Navy will not use in-water explosives in the Marpi Reef Mitigation Area and Chalan Kanoa Reef Mitigation Area year- round. – The Navy will issue an annual seasonal awareness notification message to alert ships and aircraft operating in the Marpi Reef Mitigation Area and Chalan Kanoa Reef Mitigation Area to the possible presence of increased concentrations of humpback whales from 1 December through 30 April. To maintain safety of navigation and to avoid interactions with large whales during transits, the Navy will instruct vessels to remain vigilant to the presence of humpback whales, that when concentrated seasonally, may become vulnerable to vessel strikes. Platforms will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training and testing activities and to aid in the implementation of procedural mitigation. **Agat Bay Nearshore Mitigation Area[1,2]** – The Navy will not use surface ship hull-mounted MF1 mid-frequency active sonar in the Agat Bay Nearshore Mitigation Area year-round. – The Navy will not use in-water explosives in the Agat Bay Nearshore Mitigation Area year-round.

1 Should national security present a requirement to conduct training or testing prohibited by the mitigation requirements specified in this table, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include relevant information (e.g., sonar hours, explosives use) in its annual activity reports submitted to NMFS.

2 The designated Command authority will base authorization on the unique characteristics of the area from a military readiness perspective, taking into account the importance of the area for spinner dolphins and sea turtles and the need to avoid adverse impacts to the maximum extent practicable. Furthermore, the Command authority conducting the activity will provide specific direction to operational units on required mitigation prior to conducting training or testing using in-water explosives in this area.

and fish. The Navy's reporting requirements for MF1 active sonar will aid the Navy and NMFS in continuing to analyze potential impacts of active sonar use in this area. The Agat Bay Nearshore Mitigation Area is designed to avoid or reduce potential impacts from active sonar and explosives on marine mammals (e.g., spinner dolphins), green sea turtles, and hawksbill sea turtles in an area thought to be important for foraging or other important biological life processes. Other biological resources have also been observed or are expected to be present at Chalan Kanoa Reef, including other species of marine mammals, invertebrates, and fish.

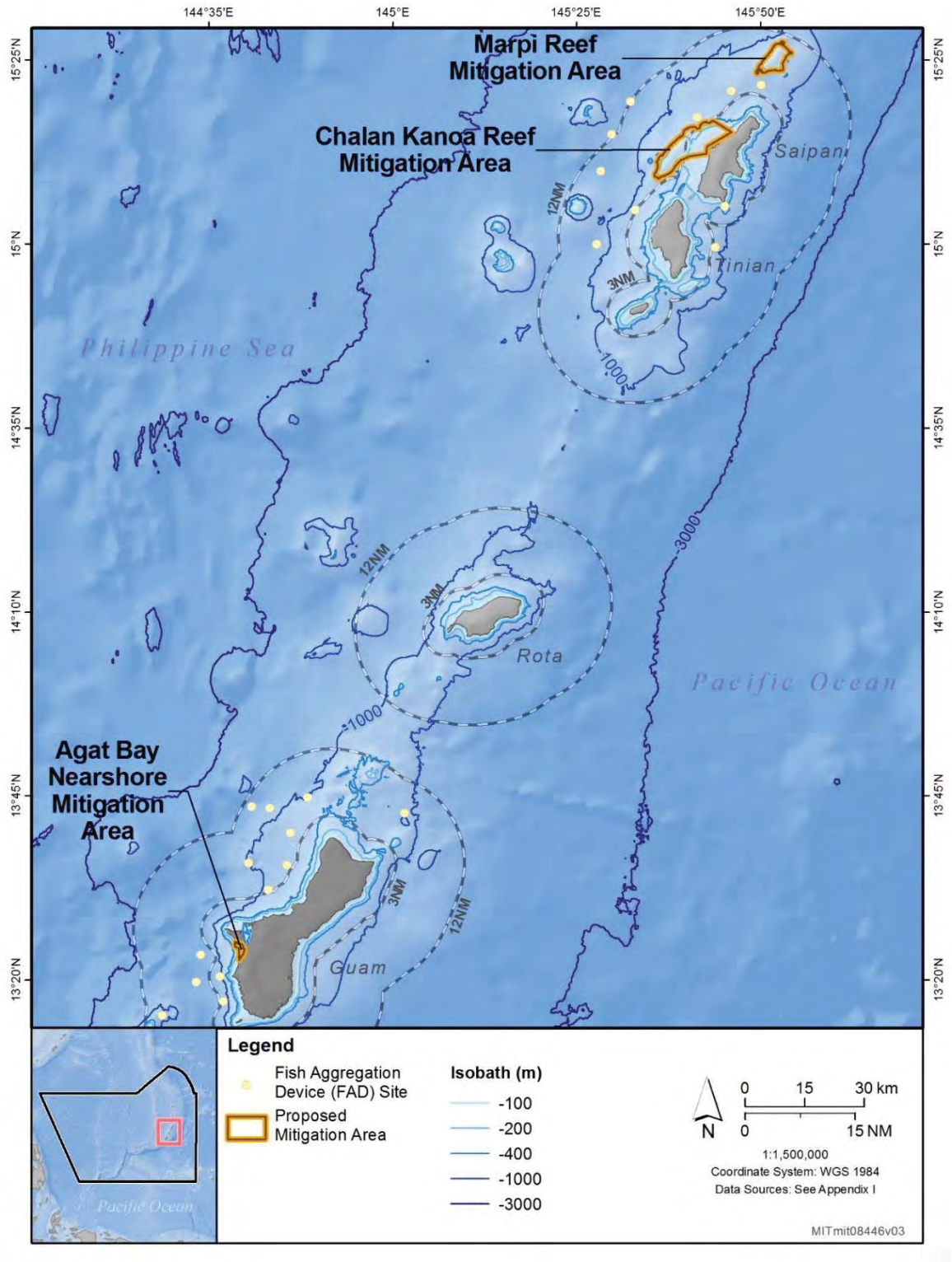


Figure 15. Marine mammal and sea turtle MITT mitigation areas

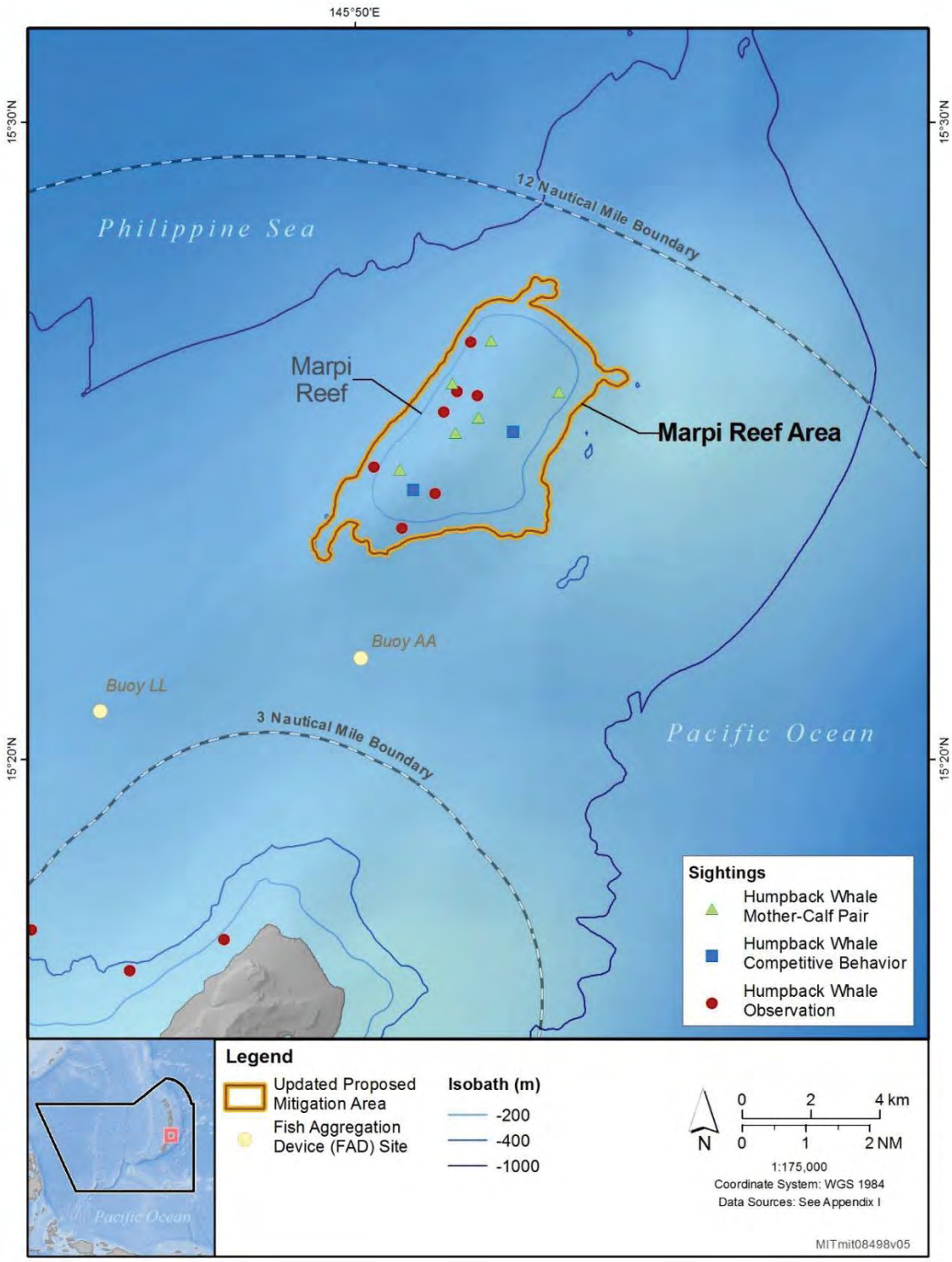


Figure 16. Marpi Reef mitigation area and humpback whale sightings locations

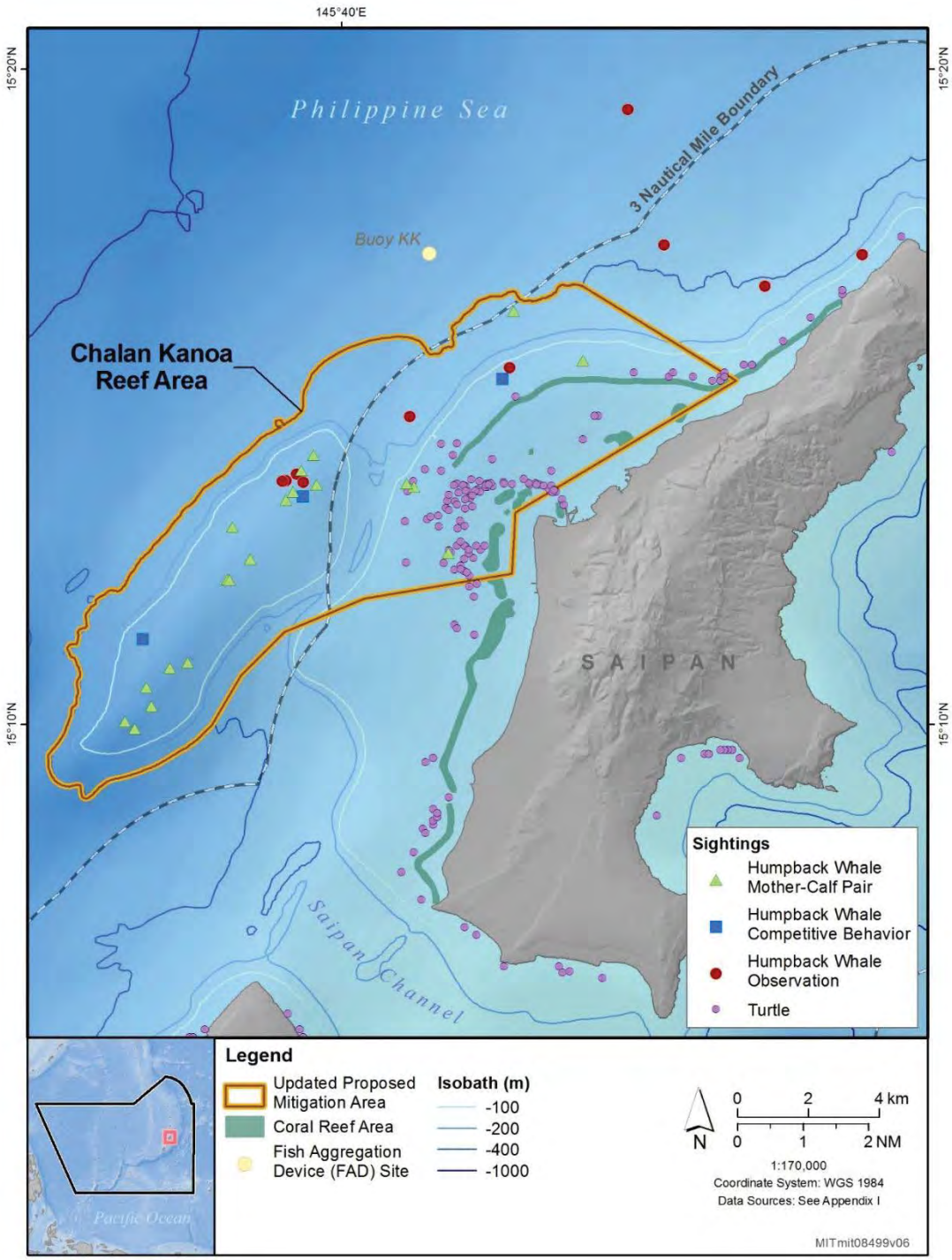


Figure 17. Chalan Kanoa Reef mitigation area with sightings locations of humpback whales and sea turtles

3.7 Promulgation of Marine Mammal Protection Act Regulations

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized by Section 101(a)(5) of the MMPA. On February 8, 2019, NMFS' Permits Division received an application from the Navy requesting regulations and a LOA for the take of 26 species of marine mammals incidental to Navy training and testing activities to be conducted in the MITT Study Area over seven years. Five of the marine mammals species requested in the LOA are also ESA-listed species. The Navy requested regulations that would establish a process for authorizing take, via a seven-year LOA, of marine mammals incidental to training and testing activities proposed to be conducted from August 2020 through August 2027.

The Permits Division proposes to promulgate regulations pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to MITT activities from August 2020 through August 2027. The regulations propose to authorize the issuance of a LOA that will allow the Navy to "take" marine mammals incidental to their training and testing activities. Issuance of the LOA was dependent on a determination that the total number of marine mammals taken by the activity as a whole would have no more than a negligible impact on the affected species or stock of marine mammals. 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 are available at the following website: https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities. This consultation considers the MMPA regulations for the Navy to "take" marine mammals incidental to MITT activities, as modified during ESA consultation. The final MMPA regulations, upon publication, will also be available at the website shown above. Note that this biological opinion was completed prior to the publication of the final MMPA regulations in the Federal Register. We anticipate that, upon publication, the MMPA regulations will reflect the mitigation and monitoring measures proposed by the Navy and/or agreed to during ESA consultation (a description of the mitigation measures is in Section 3.6 of this opinion). We also anticipate that the levels of take of ESA-listed marine mammals authorized under the final MMPA regulations and LOA will be consistent with those analyzed in this opinion. We also anticipate that the mitigation measures included in the final MMPA regulations and LOA will be consistent with mitigation measures identified as part of the proposed action in this opinion and avoidance and minimization measures specified in this opinion's ITS. Upon publication, we will review the MMPA regulations to ensure these conditions are met. If administrative changes are needed following publication of the MMPA regulations, we will update the biological opinion to reflect these changes. If more substantive changes are needed, the reinitiation triggers described in Section 14 may apply.

4 ACTION AREA

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 CFR 402.02). The Action Area encompasses the MITT Study Area, transit corridor and area outsides of the study area where the effects of stressors from Navy training and testing activities could be experienced.

The MITT Action Area is composed of three primary components: (1) the Mariana Islands Range Complex (MIRC); (2) additional areas on the high seas outside of the MIRC, including a transit corridor between the MIRC and the Hawaii Range Complex; and (3) Apra Harbor locations including pierside locations. Figure 18 shows an overview map for the entire Action Area, with the boundaries of where training and testing activities are generally expected to occur.

4.1 Mariana Islands Range Complex

A range complex is a designated set of specifically bounded geographic areas that encompasses a water component (above and below the surface) and airspace, and may encompass a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occurs. Range complexes include established ocean operating areas and special use airspace, which may be further divided to provide better control of the area and activities for safety reasons. The MIRC includes land training areas, ocean surface and subsurface areas, and special use airspace. These areas extend from the waters south of Guam to north of Pagan in the Commonwealth of the Northern Mariana Islands (CNMI), and from the Pacific Ocean east of the Mariana Islands to the Philippine Sea to the west, encompassing 501,873 NM^2 of open ocean.

4.1.1 Special Use Airspace and Air Traffic Controlled Assigned Airspace

The MIRC includes approximately 40,000 NM^2 of special use airspace. Special use airspace is airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration, 2013). Special use airspace includes restricted areas, military operations areas, and warning areas. Most of this airspace is almost entirely over the ocean and includes warning areas, and restricted areas:

- Warning Areas (W): W-517 and W-12 include approximately 11,800 NM^2 of special use airspace (Figure 19); W-11 (A/B) is approximately 10,500 NM^2 of special use airspace, and W-13 (A/B/C) is approximately 18,000 NM^2 of special use airspace.
- Restricted Area Airspace (R): Over or near land areas within the MIRC include approximately 2,463 NM^2 of special use airspace and includes restricted areas R-7201 and R-7201A, which extends in a 12 NM radius around FDM.

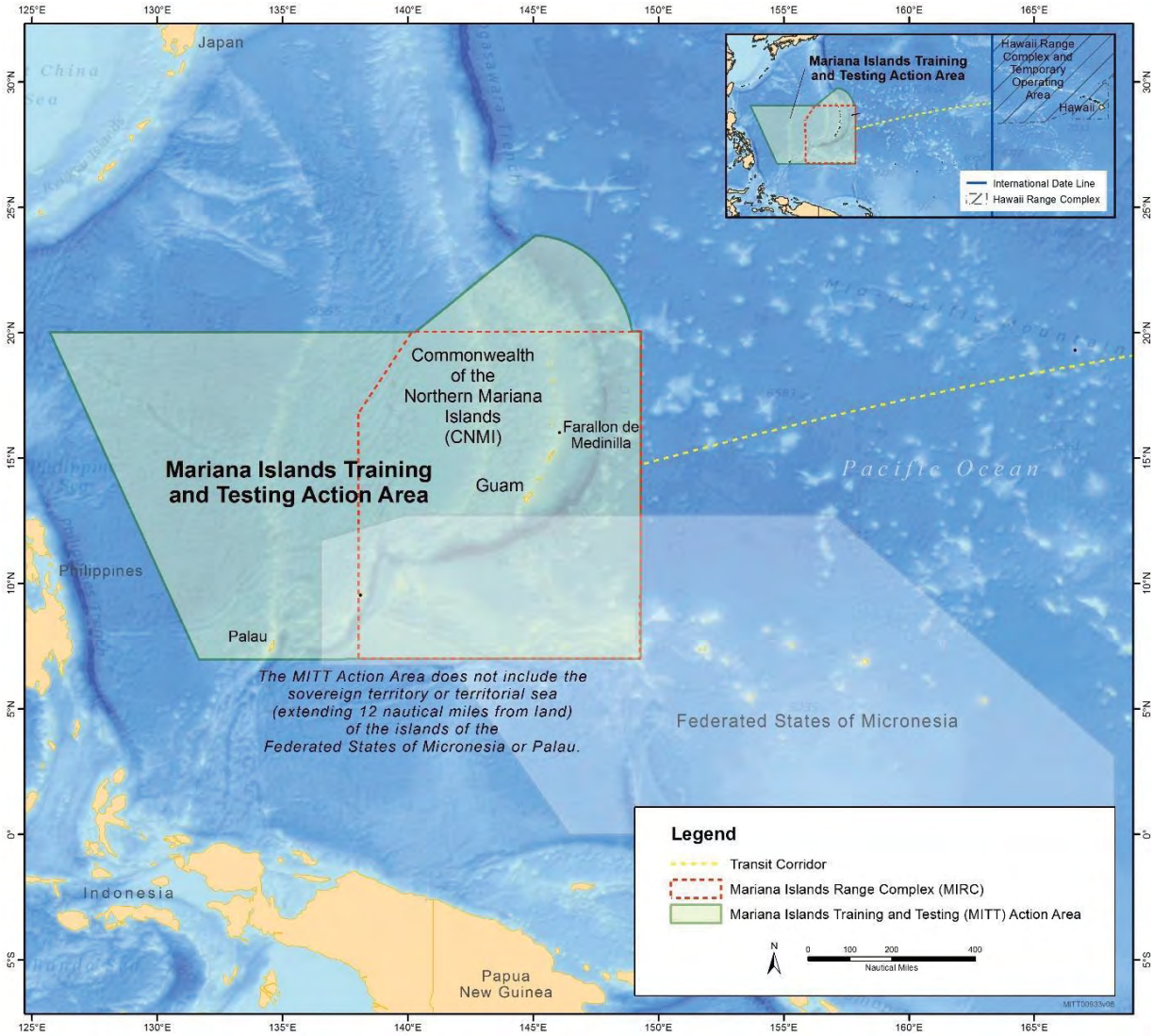


Figure 18. Mariana Islands Training and Testing Action Area with the Mariana Islands Range Complex and notional transit corridor.

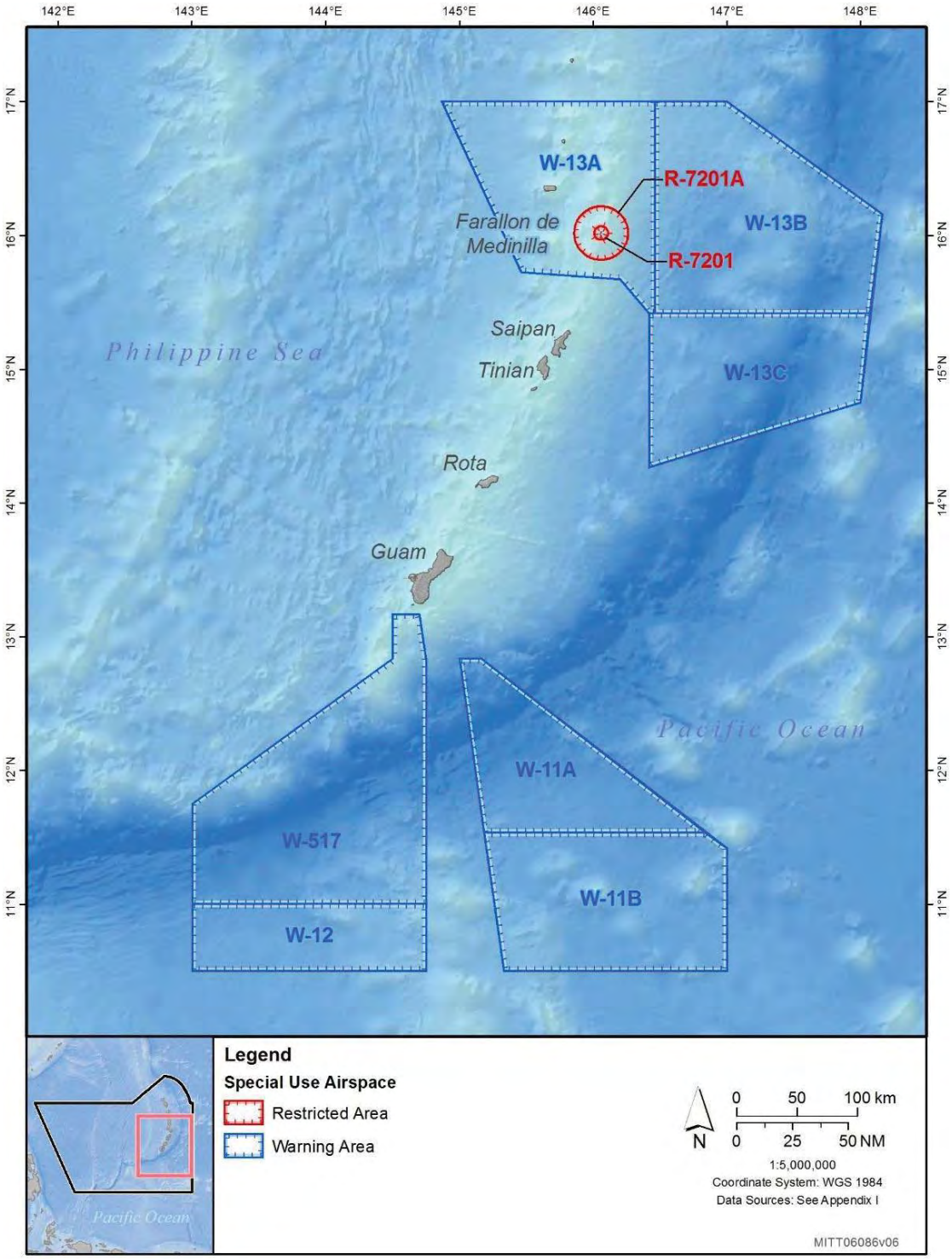


Figure 19. Mariana Islands Range Complex Airspace

4.1.2 Sea and Undersea Space

The MIRC includes the sea and undersea space from the ocean surface to the ocean floor. The MIRC also consists of designated sea and undersea space training areas, which include

designated drop zones, underwater demolition and floating mine exclusion zones, danger zones associated with live fire ranges, and training areas associated with military controlled beaches, harbors, and littoral areas.

W-517, W-12, W-11 and W-13 are designated as special use airspace where the sea space underneath may be restricted from public access during hazardous training events. Portions of the Marianas Trench Marine National Monument, established in January 2009 by Presidential Proclamation under the authority of the Antiquities Act (16 United States Code [U.S.C.] sections 431–433), lie within the MIRC and under all MIRC Warning Areas. However, the prohibitions required by the Proclamation do not apply to activities and exercises of the Armed Forces (including those carried out by the USCG).

4.1.3 Land

Commander Joint Region Marianas provides executive level installation management support to all Department of Defense components and tenants through assigned regional installations on Guam and the CNMI in support of training and testing in the Marianas, including coordination with Northern Mariana Islands Commonwealth Port Authority for logistic and operational support of aircraft and vessels; acts as the interface between the Navy and the civilian community; ensures compliance with all environmental laws and regulations, safety procedures, and equal opportunity policy; and performs other functions and tasks as assigned. While land based activities are not part of this consultation, a description of installations on Guam and the CNMI are provided for informational purposes only.

Guam

The Navy has control of approximately 28 square miles (mi^2) (72.5 square kilometers [km^2]) of land in noncontiguous properties on Guam. There are five Navy annexes: Main Base (which includes Apra Harbor Naval Complex and Main Base/Polaris Point), Naval Base Guam Munitions Site; Hospital Annex/Nimitz Hill; Naval Base Guam Telecommunications Site; and Naval Base Guam Barrigada. Andersen Air Force Base, one of the largest U.S. Air Force airfields, is located in the northern portion of the island of Guam. Andersen Air Force Base includes the main base and Northwest Field which covers 24.5 mi^2 (63.5 km^2), Andersen South 3.2 mi^2 (8.3 km^2), and Andersen Barrigada Annex 0.7 mi^2 (1.8 km^2).

Farallon de Medinilla (FDM)

FDM is a rocky and uninhabited island, approximately 1.7 mi (2.7 km) long and 0.3 mi (0.5 km) wide (Figure 20 and Figure 21). The Department of Defense leases FDM for use as a live and inert gunnery, missile, and bombing range.

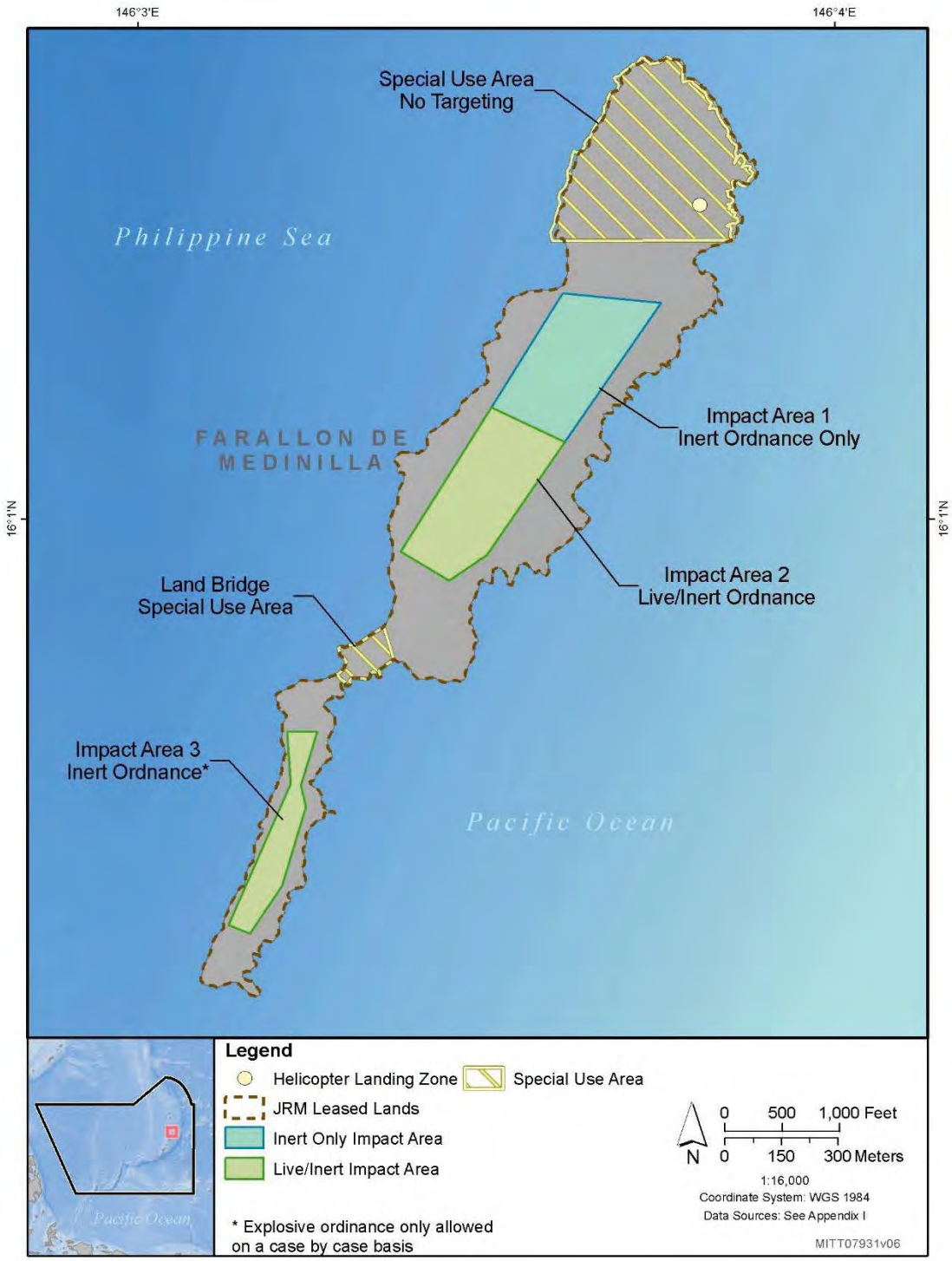


Figure 20. Farallon de Medinilla.

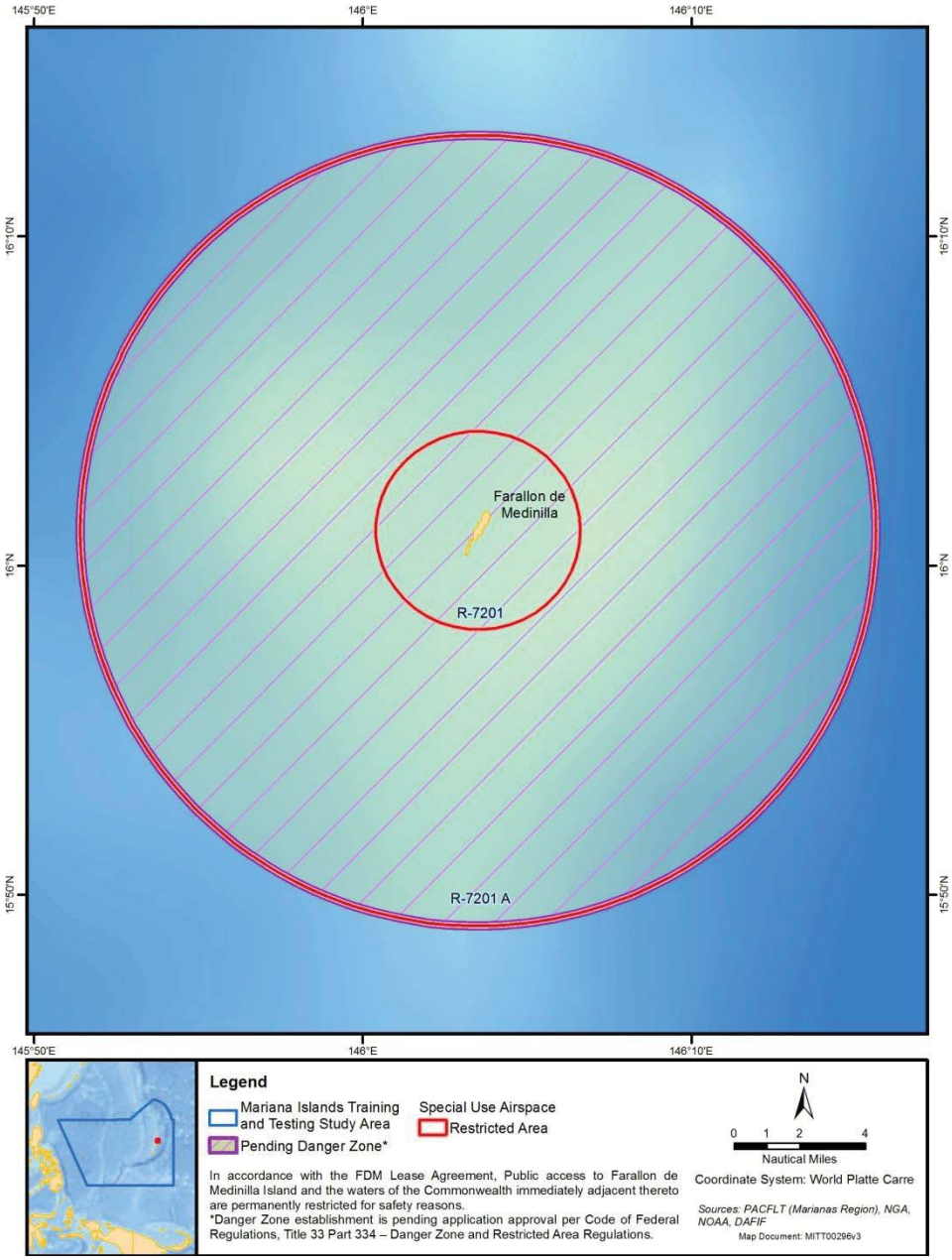


Figure 21. Farallon de Medinilla restricted area 7201, 7201A, and danger zone.

Tinian

Tinian has a land area of approximately 39 mi^2 (101 km^2). The Department of Defense leases approximately 15,347 contiguous acres (6,210.7 hectares) of northern Tinian (the Military Lease Area) for field training (Figure 22). The Military Lease Area is further divided into the Exclusive Military Use Area and the Leaseback Area.

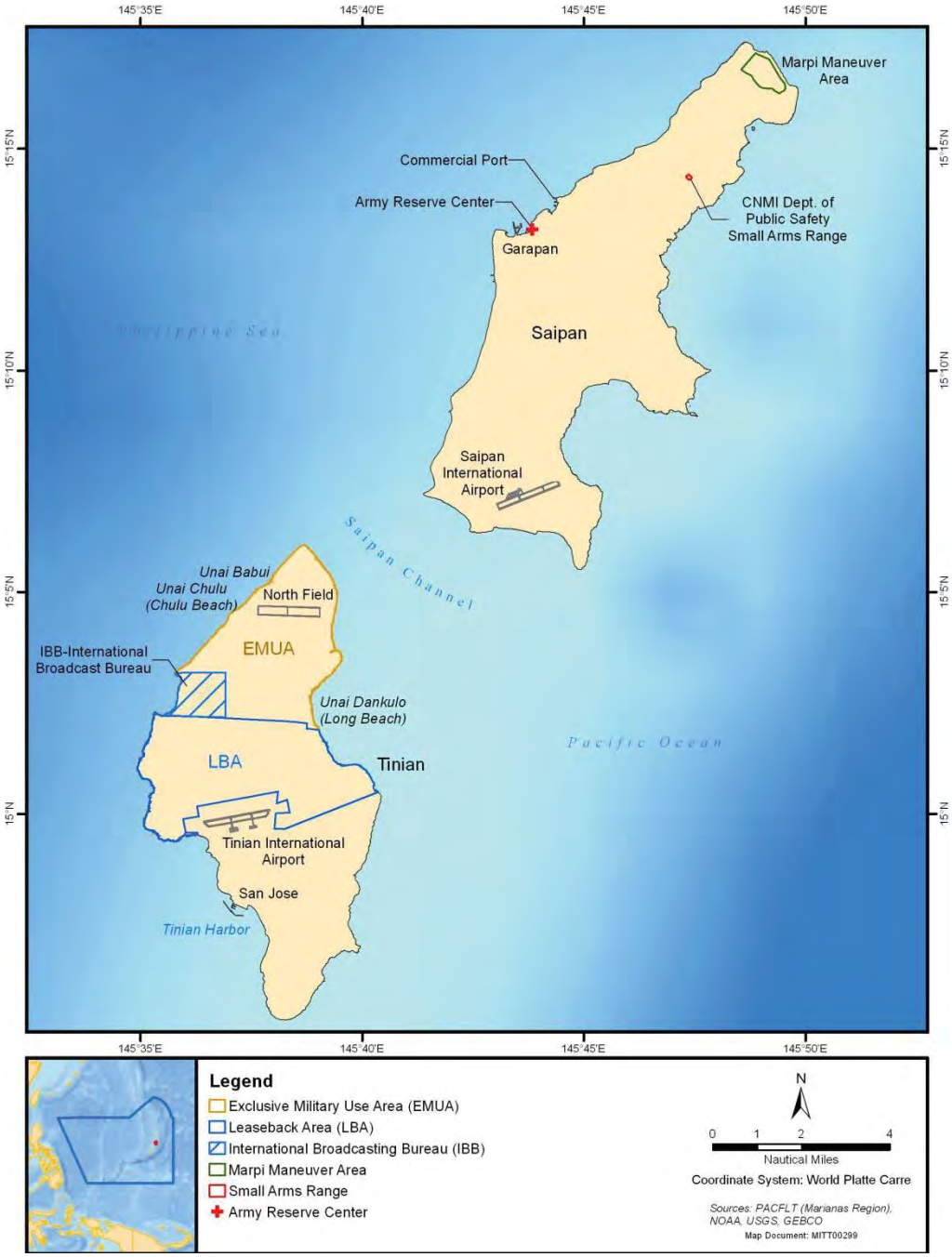


Figure 22. Tinian and Saipan

Saipan

Approximately 0.28 mi^2 (0.73 km^2) on Tanapag Harbor (commercial port) is leased by the DoD**.** The Army Reserve center is located in Garapan (Figure 22).

Rota

Rota is approximately 11 mi (17.7 km) long and 3 mi (4.8 km) wide (Figure 23). Training on Rota is scheduled with Joint Region Marianas and coordinated with Rota officials for proposed

training areas and activities. Training activities conducted on Rota typically include special warfare training and combat search and rescue training.

Figure 23. Rota.

4.2 Ocean Operating Areas Outside of the Mariana Islands Range Complex

In addition to the MIRC, the MITT Action Area includes the area to the north of the MIRC that is within the Exclusive Economic Zone (EEZ) of the CNMI and the areas to the west of the MIRC (Figure 18). The MITT Action Area also includes a transit corridor, which is a direct route between the MIRC and the Hawaii Range Complex.

Although not part of any defined range complex, the transit corridor is important to the Navy in that it provides adequate air, sea, and undersea space in which vessels and aircraft conduct training and some sonar maintenance and testing while in transit.

The transit corridor is defined by a great circle route (e.g., shortest distance) between the MIRC and the Hawaii Range Complex. While in transit and along the corridor, vessels and aircraft would, at times, conduct basic and routine unit level training such as gunnery and sonar training as long as the training does not interfere with the primary objective of reaching their intended destination. Ships also conduct sonar maintenance, which includes active sonar transmissions.

Effects of Navy training and testing activities within the portion of the transit corridor that lies within the Hawaii-Southern California Training and Testing (HSTT) Action Area were analyzed separately in the HSTT biological opinion (NMFS 2018b) but are considered as part of the environmental baseline for this biological opinion. This biological opinion addresses the effects of training and testing activities along the transit corridor outside of the HSTT Action Area.

4.3 Pierside Locations and Apra Harbor

The Action Area includes pierside locations in the Apra Harbor Naval Complex where surface ship and submarine sonar maintenance testing occur. For purposes of this biological opinion, pierside locations include channels and routes to and from the Navy port in the Apra Harbor Naval Complex (Figure 25), and associated wharves and facilities within the Navy port and shipyard.

4.4 Nearshore Training and Testing Areas

Table 45 and Figure 24 describe the nearshore training and testing activities in MITT.

Table 45. Summary of nearshore training and testing activities.

Nearshore Training and Testing Areas	Description
Finegayan Small Arms Range	Used for small arms training. Down range Surface Danger Zone extends out over the nearshore waters of Guam off Haputo Point and overlays part of the "Small Arms Safety Drop Zone" shown on NOAA Chart 81048, Guam.
Pati Point Combat Arms Training Maintenance Small Arms Range	Used for small arms training. Down range Surface Danger Zone extends out over the nearshore waters of Guam off Pati Point.
Small Arms Firing Area	An area used by surface vessel crews to conduct small arms training. This firing area is over water west of Guam, beyond 3 nm of Guam and within territorial waters, and within a Navy "Firing Danger Area" charted on NOAA Chart 81048, Guam.

Nearshore Training and Testing Areas	Description
Agat Bay Mine Neutralization Site	Used by divers training to conduct underwater detonations (UNDETs). The Exclusion Zone has a minimum 640-meter (m) radius and is located beyond 3 nm of Guam and within territorial waters.
Piti Point Mine Neutralization Site	Used by divers training to conduct UNDETs. The Exclusion Zone has a minimum 640 m radius and is located within 3 nm of Guam.
Apra Harbor UNDET Site	Used by divers training to conduct UNDETs. The Exclusion Zone has a minimum 640 m radius over water, and is located within Apra Harbor. The Glass Breakwater forms the northern edge of Exclusion Zone.
Pati Point Explosive Ordnance Disposal Range	Land site used by the Air Force to dispose of ordnance. The Exclusion Zone extends partially out of Guam off Pati Point.

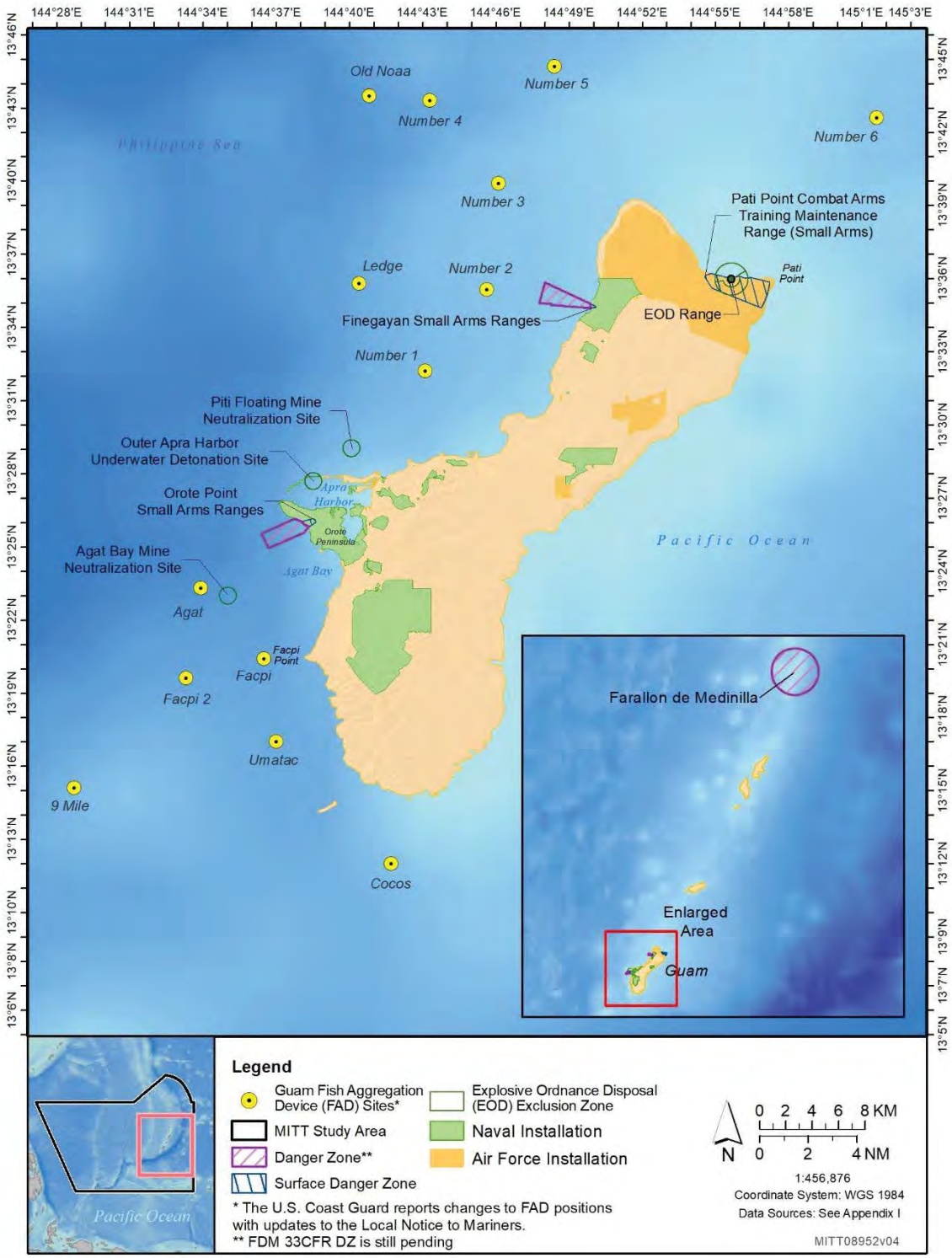


Figure 24. MITT nearshore training and testing areas.

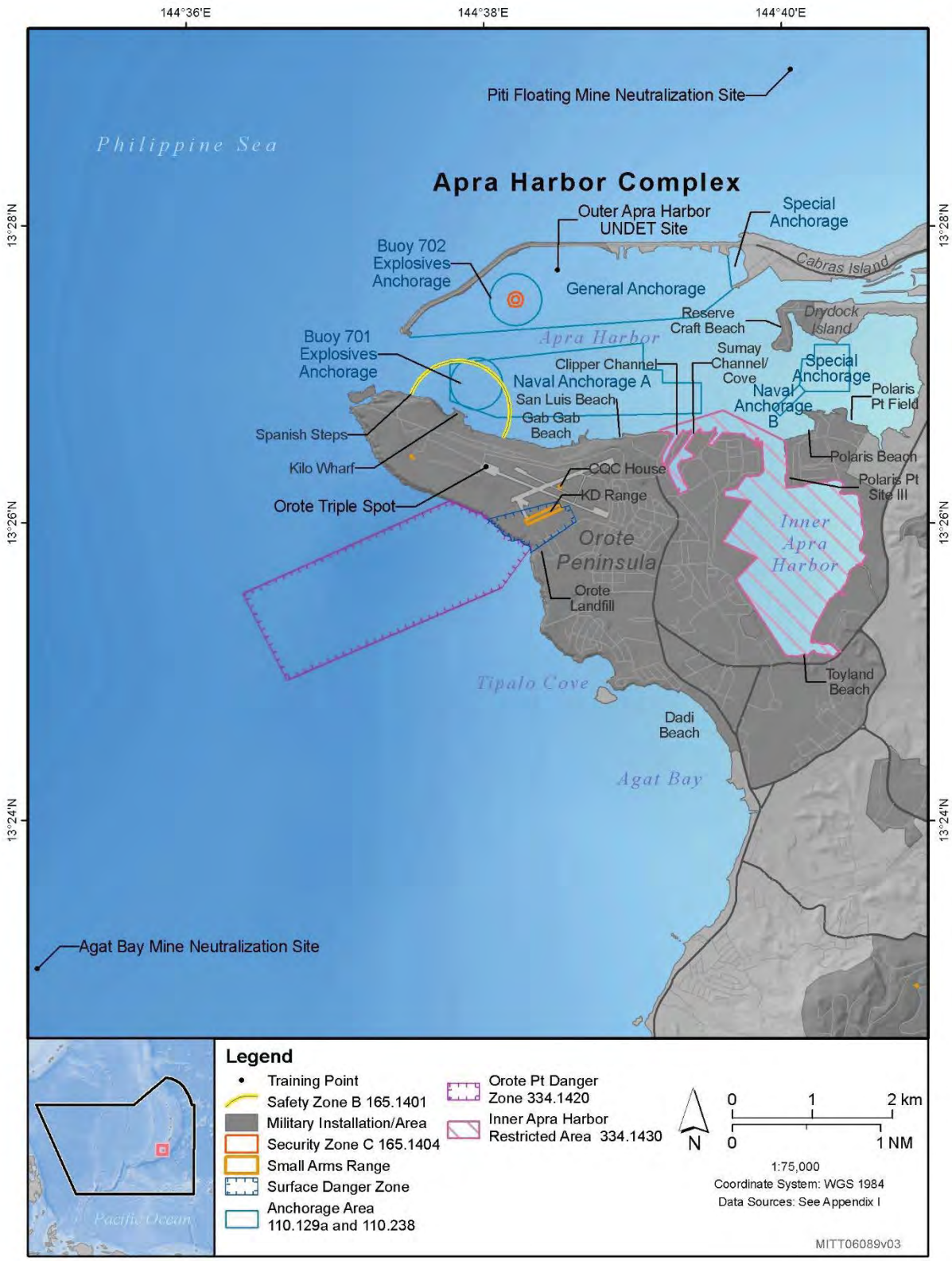


Figure 25. Apra Harbor Naval Complex (Main Base) and Main Base/Polaris Point.

5 POTENTIAL STRESSORS

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

5.1 Acoustic Stressors

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars), 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.

5.1.1 Sonar and other Transducers

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

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

The Navy employs a variety of sonars and other transducers to obtain and transmit information about the undersea environment. Under the Navy's proposed action, training and testing activities using sonar and other transducers could occur throughout the Action Area, although use would generally occur within 200 NM of shore in Navy Operating Areas, on Navy range

complexes, on Navy testing ranges, or around inshore locations (See the Description of the Proposed Action, Section 3 for more specifics on Navy sonar types and hours of use).

Anti-Submarine Warfare

Sonar used during anti-submarine warfare would impart the greatest amount of acoustic energy of any category of sonar and other transducers proposed for use by the Navy considered in this opinion. Types of sonars used to detect enemy vessels include hull-mounted, towed, line array, sonobuoy, helicopter dipping, and torpedo sonars. In addition, acoustic targets and decoys (countermeasures) may be deployed to emulate the sound signatures of vessels or repeat received signals. Some anti-submarine warfare tracking exercises and ship unit level training activities would also be conducted using simulators in conjunction with other training exercises.

Most anti-submarine warfare sonars are mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets with distance over which threats can be identified. However, some sources may use higher or lower frequencies. Duty cycles can vary widely, from rarely used to continuously active. For example, a submarine‘s mission revolves around its stealth; therefore, active sonar is used infrequently because its use would also reveal a submarine’s location. Anti-submarine warfare sonars can be wide-angle in a search mode or highly directional in a track mode.

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

While current practices focus primarily on open ocean anti-submarine warfare training, the ability to conduct training and develop tactics within littoral regions, including those within the MITT action area is critical to ensure the ongoing and future readiness of the Navy’s deployed forces and national security (Navy 2020b). The Navy may require access to near shore, shallow bathymetry for anti-submarine warfare training in order to support future readiness needs (Navy 2020b).The Navy has proposed to limit anti-submarine warfare training using active MF1 sonar to no more than 20 hours annually of MF1 sonar during anti-submarine warfare training activities within the designated humpback whale geographic mitigation areas (Chalan Kanoa Reef and Marpi Reef) combined from December-April (Navy 2020b) to minimize impacts to humpback whales. The 20 hours can be from TRACKEX events, a Small Joint Coordinated ASW exercise, or some combination of these two activities. As noted in Table 24 above, these activities would be conducted > 3 NM from land.

Mine Warfare, Small Object Detection, and Imaging

Sonars used to locate mines and other small objects, as well those used in imaging (e.g., for hull inspections or imaging of the seafloor), are typically high frequency or very high frequency. Higher frequencies allow for greater resolution and, due to their greater attenuation, are most effective over shorter distances. Mine detection sonar can be deployed (towed or vessel hull-

mounted) at variable depths on moving platforms (ships, helicopters, or unmanned vehicles) to sweep a suspected mined area. Hull-mounted anti-submarine sonars can also be used in an object detection mode known as "Kingfisher" mode. Sonars used for imaging are usually used in close proximity to the area of interest, such as pointing downward near the seafloor.

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

Navigation and Safety

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

Communication

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

5.1.2 Explosives

The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging to ESA-listed resources. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive warhead, the type of explosive material, the boundaries and characteristics of the propagation medium, and, in water, the detonation depth. The NEW, the explosive power of a charge expressed as the equivalent weight of trinitrotoluene, accounts for the first two parameters.

Explosive detonations during training and testing activities associated with high-explosive munitions include, but are not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations associated with torpedoes and sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Detonations would typically occur in waters greater than 200 ft. in depth, and greater than 3 NM from shore, with the exception of existing mine warfare areas, including Outer Apra Harbor, Piti, and Agat Bay UNDETs. Explosive detonations associated with bombs, missiles, and naval gun shells could occur in the air (see below) or near the water's surface.

Propagation of explosive pressure waves in water is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity, which affect how the pressure waves are reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher frequency components of explosive broadband noise can propagate. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its exposure analysis that consider sound source characteristics and varying ocean conditions across the Action Area. The Navy's acoustic modeling approach is described further in Section 2.2.1 of this opinion and in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018c).

Explosions in the Air

Explosions in air include detonations of projectiles and missiles during surface-to-air gunnery and air-to-air missile exercises conducted during air warfare. These explosions typically occur far above the water surface. Some typical types of explosive munitions that would be detonated in air during Navy activities are shown in Table 46. In air, the propagation of impulsive noise from an explosion is highly influenced by atmospheric conditions, including temperature and wind.

Table 46. Typical air explosive munitions during Navy activities

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

[1] Mission Design Series and popular name shown for missiles.
[2] Most medium and large caliber projectiles used during training and testing activities do not contain high explosives.
Notes: AMRAAM = Advanced Medium-Range Air-to-Air Missile, HARM = High-Speed Anti-Radiation Missile, HE-ET = High Explosive-Electronic Time, lb. = pound(s), ft. = foot/feet

5.1.3 Vessel Noise

Potential impacts of vessel noise on ESA-listed species include masking of other biologically relevant sounds, physiological stress, and changes in behavior. Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and SPLs at a source will vary according to speed, burden, capacity and length (Kipple and Gabriele 2007; Mckenna et al. 2012; Richardson et al. 1995b).Without considering differences in sound fields associated with sources used during an activity (e.g. active sonar), the available evidence suggests that major training exercises, unit- and intermediate-level exercises, and testing activities would represent different stress regimes because of differences in the number of vessels involved, vessel maneuvers, and vessel speeds.

Naval vessels (including ships and small craft) produce low-frequency, broadband underwater sound, though the exact level of noise produced varies depending on the nature, size, and speed of the ship. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz and Filadelfo 2011). Mckenna et al. (2012) determined that container ships produced broadband source levels around 188 dB re 1 μPa rms and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 μPa rms (Mintz and Filadelfo 2011; Urick 1983) (Richardson et al. 1995b). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (Mintz and Filadelfo 2011; Richardson et al. 1995b; Urick 1983). Vessels ranging from 135 to 337 m (Nimitz-class aircraft carriers, for example, have lengths of about 332 m) generate peak source sound levels from 169 to 200 dB re 1 μPa rms between eight Hz and 430 Hz. Sound produced by vessels will typically increase with speed. During training and testing, speeds of most large naval vessels (greater than 60 ft.) generally range from 10 to 15 knots. Navy ships will, on occasion, operate at higher speeds within their specific operational capabilities.

Navy vessels represent a relatively small amount of overall vessel traffic in the action area. Over the 5-year period between 2014 and 2018, there were cumulatively 1,497 Navy vessel transits through Apra Harbor (Navy 2019e). This represents 14 percent of all vessel transits, or about six times less than commercial shipping. Navy vessels may represent an even smaller amount of overall vessel traffic noise in the action area because many Navy ships incorporate quieting technology that other vessels (e.g., commercial ships) do not (Mintz and Filadelfo 2011). For example, surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection. The Navy implements a “Buy Quiet” policy for equipment aboard ships which requires designers and engineers to obtain noise emission data before purchasing to choose the quietest available. The Navy also researches and implements technology improvements that minimize noise. For example, propellers used on Navy ships have been subject to design improvements to reduce excitation. The average acoustic signature for a Navy vessel is 163 dB re 1 μPa, while the

average acoustic signature for a commercial vessel is 175 dB re 1 μPa (Mintz and Filadelfo 2011).

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in training and testing may consist of a single vessel involved in unit-level activity for a few hours or multiple vessels involved in a major training exercise that could last a few weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration.

Exposure of ESA-listed species to vessel noise would be greatest in the areas of highest vessel traffic in close proximity to ports. For the MITT Action Area, there is one port on Guam as well as Naval Base Guam, and three ports within the CNMI (Port of Rota, Port of Tinian, and Port of Saipan). Large hull civilian commercial ships and Navy ships are mostly associated with transits into and out of Apra Harbor on the southwest side of Guam. Navy vessels do not berth at any other locations within the MITT Action Area. Within the CNMI, the Port of Rota is located on the southwestern tip of the island. It is a very small, poorly sheltered port with a pierside water depth of six to ten ft. which limits the size of vessels that can access the pier. The Port of Rota is mainly used for ferry boats transporting tourists and residents from its sister island, Tinian. The Port of Tinian is a small, well sheltered port. Mobil Oil operates a fuel plant at the port, and a ferry service transports tourists from Saipan to Tinian. The Port of Saipan is the largest of the three CNMI ports. The port of Saipan is on the southwest shore and houses commercial ships, small local boats or ferries, and military vessels.

5.1.4 Aircraft Noise

Many of the activities the Navy conducts in the MITT Action Area involve some level of activity from aircraft that include helicopters, maritime patrols, and fighter jets. Low-flying aircraft produce sounds that marine mammals and sea turtles can potentially hear when they occur at or near the ocean’s surface. Helicopters generally tend to produce sounds that can be heard at or below the ocean’s surface more than fixed-wing aircraft of similar size and larger aircraft tend to be louder than smaller aircraft. Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. Sounds from aircraft would not have physical effects on marine animals but represent acoustic stimuli (primarily low-frequency sounds from engines and rotors) that have been reported to affect the behavior of some marine mammals and sea turtles. There are few studies of the responses of marine animals to air traffic and the few that are available have produced mixed results. Some investigators report responses while others report no responses.

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 47 provides source levels for some typical aircraft used during training and testing in the action area and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D during takeoff.

Table 47. Representative aircraft sound characteristics (Navy 2018c).

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

** Estimate based on in-air level*
***Average SEL*
Notes: dB re 1 μPa = decibel(s) referenced to 1 micropascal, dBA re 20 μPa = A-weighted decibel(s) referenced to 20 micropascals

Sound generated in air is transmitted to water primarily in a narrow area directly below the source. A sound wave propagating from any source must enter the water at an angle of incidence of about 13 degrees or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick 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. Air combat maneuver altitudes generally range from 5,000 to 30,000 ft, and typical airspeeds range from very low (less than 200 knots) to high subsonic (less than 600 knots). Sound exposure levels at the sea surface from most air combat maneuver overflights are expected to be less than 85 A-weighted dBs (based on an F/A-18 aircraft flying at an altitude of 5,000 ft and at a subsonic airspeed (400 knots). Exposure to fixed-wing aircraft noise in water would be brief (seconds) as an aircraft quickly passes overhead.

Helicopters

Noise generated from helicopters is transient in nature and variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft. Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air and is estimated to be 125 dB re 1 μPa at 1 m below water surface for a UH-60 hovering 82 ft (25 m) altitude (Kufeld and Bousman 2005).

Helicopter unit level training typically entails single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about two to four hours. Some events require low-altitude flights over a defined area, such as mine countermeasure activities deploying towed systems. Most helicopter sorties associated with mine countermeasures would occur at altitudes as low as 75-100 ft. Likewise, in some anti-submarine warfare events, a dipping sonar is deployed from a line suspended from a helicopter hovering at low altitudes over the water.

Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Supersonic aircraft flights are not intentionally generated below 30,000 ft unless over water and are generally conducted more than 30 NM from inhabited coastal areas or islands. 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.

Several factors that influence sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (Navy 2017b).

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 2017b). Atmospheric conditions such as wind speed and direction, and air temperature and pressure can also influence the sound propagation of a sonic boom.

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

In air, the energy from a sonic boom is concentrated in the frequency range from 0.1 to 100 Hz. The underwater sound field due to transmitted sonic boom waveforms is primarily composed of low-frequency components (Sparrow 2002), and frequencies greater than 20 Hz have been found to be difficult to observe at depths greater than 33 ft (10 m) (Sohn et al. 2000). F/A-18 Hornet supersonic flight was modeled to obtain peak SPLs and energy flux density at the water surface and at depth (Laney and Cavanagh 2000). These results are shown in Table 48.

Table 48. Sonic boom underwater sound levels modeled for supersonic flight from a representative aircraft.

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

** Mach number equals aircraft speed divided by the speed of sound.*
Notes: SPL = sound pressure level, dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 1 µPa²-s = decibel(s) referenced to 1 micropascal squared seconds.
[1] Equivalent to SEL for a plane wave.

5.1.5 Weapons Firing, Launch and Impact Noise

The Navy trains and tests using a variety of weapons. Depending on the weapon, noise may be produced at launch or firing, while in flight, or upon impact. Other devices intentionally produce noise to serve as a non-lethal deterrent. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by explosives, both in air and water, are discussed in Section 5.1.2. Noise associated with large-caliber weapons firing and the impact of non-explosive practice munitions or kinetic weapons would occur at locations greater than 12 NM from shore in warning areas or special use airspace for safety reasons, with the exception of areas near FDM. Small- and medium-caliber weapons firing could occur throughout the Action Area in identified training areas. Examples of some types of weapons noise are shown in Table 49.

Table 49. Examples of noise from weapons (Navy 2018b).

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

Sources: [1]Yagla and Stiegler (2003); [2]U.S. Department of the Army (1999); [3]U.S. Department of the Navy (2013).
Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 20 µPa = decibel(s) referenced to 20 micropascals, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals

Firing a gun produces a muzzle blast in air that propagates away from the gun with strongest directivity in the direction of fire. As the pressure from the muzzle blast from a ship-mounted large caliber gun propagates in air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. Most sound enters the water in a narrow cone beneath the sound source (within about 13 to 14 degrees of vertical), with most sound outside of this cone being totally reflected from the water surface. In-water sound levels were measured during the muzzle blast of a 5-in large caliber naval gun. The highest possible sound level in the water (average peak SPL of 200 dB re 1 µPa, measured 5 ft below the surface) was

obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla and Stiegler 2003). The unweighted SEL would be expected to be 15 to 20 dB lower than the peak pressure, making the highest possible SEL in the water about 180 to 185 dB re 1 μPa^2-s directly below the muzzle blast. Configuration of the 5-inch gun on Navy ships also affects how much sound from muzzle blast could enter the water. On cruisers, when swung out to either side, the barrel of the gun extends beyond the ship deck and over water. On destroyers, of which there are more of in the Navy's fleet, when swung out to either side the barrel of the gun is still over the ship's deck. Other gunfire arrangements, such as with smaller-caliber weapons or greater angles of fire, would result in less sound entering the water. The sound entering the water would have the strongest directivity directly downward beneath the gun blast, with lower sound pressures at increasing angles of incidence until the angle of incidence is reached where no sound enters the water.

Supersonic 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. The bow shock wave itself travels at the speed of sound in air. The projectile bow shock wave created in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65 degrees) behind the projectile in the direction of fire (Pater 1981). Like sound from the gun muzzle blast, sound waves from a projectile in flight could only enter the water in a narrow cone beneath the sound source, with in-air sound being totally reflected from the water surface outside of the cone. The region of underwater sound influence from a single traveling shell would be relatively narrow, and the duration of sound influence would be brief at any location.

Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Any object dropped in the water would create a noise upon impact, depending on the object's size, mass, and speed. Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. A significant portion of an object's kinetic energy would be lost to splash, any deformation of the object, and other forms of non-mechanical energy (Mclennan 1997). The remaining energy could contribute to sound generation. Most objects would be only momentarily detectable, but some large objects traveling at high speeds could generate a broadband impulsive sound upon impact with the water surface. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

Although not a weapon, the Long Range Acoustic Device (and other hailing and deterrent sources) is considered along with in-air sounds produced by Navy sources. The Long Range Acoustic Device is a communication device that can be used to warn vessels from continuing towards a high value asset by emitting loud sounds in air. The system would typically be used in

training activities near shore, and use would be intermittent during these activities. Source levels at 1 m range between 137 dBA re 1 μPa for small portable systems and 153 dBA re 1 μPa for large systems. Sound would be directed within a 30 to 60° wide zone and would be directed over open water.

5.2 Energy Stressors

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

5.2.1 Electromagnetic Devices

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

Generally, voltage used to power these systems is around 30 volts. Since saltwater is an excellent conductor, just 35 volts (capped at 55 volts) is required to generate the current needed to power the systems. These are considered safe levels for marine species due to the low electric charge relative to saltwater (Navy 2018b). The static magnetic field generated by the mine neutralization devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 2,300 microteslas[5]. This level of electromagnetic density is very low compared to magnetic fields generated by other everyday items (e.g., the magnetic field generated is between the levels of a refrigerator magnet, which is 15,000 to 20,000 microteslas).

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

A radar system is an electromagnetic device that emits radio waves to detect and locate objects. In most cases, basic radar systems operate by generating pulses of radio frequency energy and transmitting these pulses via directional antennae into space (Courbis and Timmel 2008). Some of this energy is reflected by the target back to the antenna, and the signal is processed to provide useful information to the operator. Radars come in a variety of sizes and power, ranging from wide-band milliwatt systems to very high-power systems that are used primarily for long-range search and surveillance (Courbis and Timmel 2008). In general, radars operate at radio frequencies that range between 300 MHz and 300 gigahertz, and are often classified according to

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

their frequency range. Navy vessels commonly operate radar systems which include S-band and X-band electronically steered radar. S-band radar serves as the primary search and acquisition sensor capable of tracking and collecting data on a large number of objects while X-band radar can provide high resolution data on particular objects of interest and discrimination for weapons systems. Both systems employ a variety of waveforms and bandwidths to provide high quality data collection and operational flexibility (Baird et al. 2016).

The Navy assumes that most platforms (e.g., vessels) associated with proposed training and testing activities will be transmitting from a variety of in-air electromagnetic devices at all times while they are underway, with very limited exceptions (Navy 2018b). Most of these transmissions (e.g., for routine surveillance, communications, and navigation) will be at low power. High-power settings are used for a small number of activities including ballistic missile defense training, missile and rocket testing, radar and other system testing, and signature analysis operations. In-air electromagnetic energy as part of the proposed action would be widely dispersed throughout the Action Area, but more concentrated near ports, naval installations, and range complexes.

5.2.2 Lasers

Low-energy lasers are used to illuminate or designate targets, to measure the distance to a target, to guide weapons, to aid in communication, and to detect or classify mines. High-energy lasers are a newly proposed stressor within the MITT Action Area. High-energy laser weapons testing involves the use of directed energy as a weapon against small surface vessels and airborne targets. They would be employed from surface ships and are designed to create small but critical failures in potential targets. High-energy lasers are expected to be used at short ranges. If there is a miss from a boat target, the laser beam may strike the water in the 200 m (219 yd) to 6.5 km (3.5 NM) range or more, assuming an engagement range of 200 m (219 yd) to 5 km (2.7 NM). At these ranges, the low angles to the water will reflect most of the laser energy. The laser will lose a significant amount of energy within only a few cm from the surface. The penetration will raise the water temperature based on the beam's incident angle to the surface of the water near the beam. Only the water in the immediate vicinity of the laser beam just under the surface would be affected. The hot water would quickly mix with the cooler surrounding water. As a result, striking the ocean with a high-energy laser beam should not be a hazard to underwater marine life, except at or very near the laser beam just below the ocean surface.

5.3 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors described in the sections below include vessel strike, in-water devices, military expended materials, sea-floor devices, cavitation from vessels, precision anchoring, and personnel disturbance.

5.3.1 Vessel Strike

Vessels used by the Navy during training and testing activities include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 ft to over

1,000 ft. Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than 40 ft. [12 m] in length), which are all support craft, have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of these parameters. There are a few specific events including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the joint high speed vessel (which will operate at an average speed of 35 knots) where vessels would operate at higher speeds. Table 50 provides examples of the types of vessels, length, and speeds typically used in Navy testing and training activities.

Table 50. Representative vessel types, lengths, and speeds (Navy 2018b).

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

Navy vessels represent a relatively small amount of overall vessel traffic in the action area. Over the 5-year period between 2014 and 2018, there were cumulatively 1,497 Navy vessel transits through Apra Harbor. This represents 14 percent of all vessel transits, or about six times less than commercial shipping. The annual average number of Navy vessel transits over the 5-year interval was 299 transits. Across all warfare areas and activities, the Navy estimates a total of 493 days (i.e., one day equals 24 hours) of at-sea time would occur annually within the MITT Action Area. Amphibious Warfare activities account for 60.7 percent of total surface ship days, MTEs account for 25.4 percent, Anti-Surface Warfare activities account for 8.4 percent, and Anti-Air Warfare, Anti-Submarine Warfare and other activities (sonar maintenance, anchoring) account for about two percent each (Navy 2019a).

The number of military vessels in the action area at any given time varies and is dependent on local training or testing requirements. Vessel movement as part of the proposed action would be widely dispersed throughout the Action Area, but more concentrated in portions of the Action Area near ports, naval installations, range complexes and testing ranges. Exposure of ESA-listed species to vessel strike would be greatest in the areas of highest vessel traffic in close proximity to ports. For the MITT Action Area, there is one port on Guam as well as Naval Base Guam, and three ports within the CNMI (Port of Rota, Port of Tinian, and Port of Saipan). Large hull civilian commercial ships and Navy ships are mostly associated with transits into and out of Apra Harbor on the southwest side of Guam. While the Navy ships assigned to any particular homeport change periodically, there are presently no Navy surface warships homeported in Guam. The types of vessels currently homeported in Apra Harbor include submarines, support vessels like a submarine tender and a military sealift (i.e., logistics) unit, and small vessels like coastal riverine craft.

The western approaches to Apra Harbor are the central corridor of vessel movements in the MITT Action Area, as visiting, transiting, homeported vessels pull in and out for port calls and resupply. Depending on a given exercise, many of the participating ships could use Apra Harbor prior to or after the event depending on operational schedules. A significant amount of Mine Warfare events with vessel movements would be more likely west of Guam and adjacent to Apra Harbor, depending on the event.

Navy vessels do not berth at any other locations (besides Apra Harbor) within the MITT Action Area. Within the CNMI, the Port of Rota is located on the southwestern tip of the island. It is a very small, poorly sheltered port with a pierside water depth of six to ten ft. which limits the size of vessels that can access the pier. The Port of Rota is mainly used for ferry boats transporting tourists and residents from its sister island, Tinian. The Port of Tinian is a small, well sheltered port. Mobil Oil operates a fuel plant at the port, and a ferry service transports tourists from Saipan to Tinian. The Port of Saipan is the largest of the three CNMI ports. The port of Saipan is on the southwest shore and houses commercial ships, small local boats or ferries, and military vessels.

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in training and testing may consist of a single vessel involved in unit-level activity for a few hours or multiple vessels involved in a major training exercise that could last a few weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration. Activities range from involving one or two vessels to several vessels operating over various time frames and locations. Vessel movements in the action area fall into one of two categories; (1) those activities that occur in the offshore component of the Action Area and (2) those activities that occur in inshore waters.

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

The Navy employs several actions to minimize collisions between surface vessels and ESA-listed animals that might occur in the action area. These measures include lookouts and watchstanders on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales to alert other ships in the area. Navy policy (Chief of Naval Operations Instruction 3100.6H) requires participating vessels to report all whale strikes. That information is collected by the Office of the Chief of Naval Operations Energy and Environmental Readiness Division and cumulatively provided to NMFS on an annual basis. In addition, the Navy and NMFS have standardized regional reporting protocols for communicating to NMFS stranding coordinators information on any ship strikes as soon as possible. These communication procedures will remain in place as part of this proposed action.

5.3.2 Military Expended Materials, In-Water Devices and Seafloor Devices

Military expended materials that may cause physical disturbance or strike include: (1) all sizes of non-explosive practice munitions; (2) fragments from explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, and expendable targets. In-water devices include unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles and unmanned undersea vehicles and towed devices. These devices are self-propelled and unmanned or towed through the water from a variety of platforms, including helicopters, unmanned underwater vehicles, and surface ships. In-water devices are generally smaller than most Navy vessels, ranging from several inches to about 50 ft, and can operate anywhere from the water surface to the benthic zone. Seafloor devices represent items used during training or testing activities that are deployed onto the seafloor and recovered. These items include moored mine shapes, anchors, and bottom placed instruments. In certain cases, weights that anchor a device would be expended when the device is recovered (e.g., pop-up buoys). Seafloor devices are either stationary or move very slowly along the bottom.

5.3.3 Cavitation from Vessels and In-Water Devices

Cavitation is a phenomenon in which rapid changes of pressure in a liquid lead to the formation of small vapor-filled cavities, in places where the pressure is relatively low. When subjected to higher pressure, these cavities (called "bubbles" or "voids") collapse and can generate an intense shock wave.

5.3.4 Anchoring

The Navy's use of anchors, anchor chains and mooring chains can result in physical disturbance and strike of seafloor resources. Precision anchoring involves surface ship crews releasing and retrieving anchors in designated locations.

5.3.5 Personnel Disturbance

Personnel disturbance accounts for the potential for physical impacts on the environment from personnel involved in training or testing activities. The Navy's proposed action includes 441 annual events that include the potential for personnel disturbance (Navy 2019e). During some activities, such as amphibious activities, military personnel approaching land from the ocean may cause disturbance in the shallow water habitats from walking, standing, or swimming in the nearshore waters during activities such as raids and assaults. For example, as amphibious boats approach a beach, military personnel may be required to exit the boat, stand up, and walk to the beach landing objective. The Navy has indicated that contact with hard bottom substrate in nearshore waters, such as coral reefs, would be avoided or reduced to the greatest extent possible.

5.4 Entanglement Stressors

The Navy proposes to utilize a variety of materials that could pose an entanglement risk to ESA-listed species including fiber optic cables, guidance wires, and decelerators/parachutes. In addition, sonobuoy wires, not previously identified as an entanglement stressor in the NMFS MITT 2017 biological opinion, can pose a risk of entanglement. 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 certain types of military expended materials could potentially result in negative sub-lethal effects and mortality. For one of these materials to result in entanglement it must be long enough to wrap around the appendages of marine animals. Another critical factor is rigidity; the item must be flexible enough to wrap around appendages or bodies.

5.4.1 Wires and Cables

Fiber optic cables are expended during Navy training and testing associated with remotely operated mine neutralization activities. The length of the expended tactical fiber would vary (up to about 3,000 m) depending on the activity. Tactical fiber has an 8-micrometer (µm) (0.008 mm) silica core and acylate coating, and looks and feels like thin monofilament fishing line. Other characteristics of tactical fiber are a 242-µm (0.24 mm) diameter, 12-lb tensile strength, and 3.4-mm bend radius (Navy 2017b). Tactical fiber is relatively brittle; it readily breaks if knotted, kinked, or abraded against a sharp object. Deployed tactical fiber will break if looped beyond its bend radius (3.4 mm), or exceeds its tensile strength (12 lb.). If the fiber becomes looped around an underwater object or marine animal, it will not tighten unless it is under tension. Such an event would be unlikely based on its method of deployment and its resistance to looping after it is expended. The tactical fibers are often designed with controlled buoyancy to

minimize the fiber's effect on vehicle movement. The tactical fiber would be suspended within the water column during the activity, and then be expended and sink to the seafloor (effective sink rate of 1.45 centimeters (cm) per second (Navy 2017b)) where it would be susceptible to abrasion and burial by sedimentation.

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

Sonobuoys consist of a surface antenna and float unit and a subsurface hydrophone assembly unit. The two units are attached through a thin-gauge, dual-conductor, and hard-draw copper strand wire, which is then wrapped by hollow rubber tubing or a bungee in a spiral configuration. The tensile breaking strength of the wire and rubber tubing is no more than 40 lbs. The length of the wire is housed in a plastic canister dispenser, which remains attached upon deployment. The length of wire that extends out is no more than 1,500 ft and is dependent on the water depth and type of sonobuoy. Attached to the wire is a kite-drogue and damper disk stabilizing system made of non-woven nylon fabric. The nylon fabric is very thin and can be broken by hand. The wire runs through the stabilizing system and leads to the hydrophone components. The hydrophone components may be covered by thin plastic netting depending on the type of sonobuoy, but pose no entanglement risk. Each sonobuoy has a saltwater-activated polyurethane float that inflates when the sonobuoy is submerged and keeps the sonobuoy components floating vertically in the water column below it. Sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor.

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

5.4.2 Decelerators and Parachutes

Decelerators/parachutes used during training and testing activities are classified into four different categories based on size: small, medium, large, and extra-large (Table 51). Aircraft-

launched sonobuoys and lightweight torpedoes 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 smaller (18 inches) cruciform shape decelerators/parachutes associated with sonobuoys. Illumination flares use medium-sized decelerators/parachutes, up to approximately 19 ft in diameter. Both small- and medium-sized decelerators/parachutes are made of cloth and nylon, many with weights on their short attachment lines to speed their sinking. At water impact, the decelerator/parachute assembly is expended and sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Group 2005). Once settled on the bottom, the canopy may temporarily billow if bottom currents are present.

Table 51. Size categories for decelerators/parachutes expended during training and testing activities (Navy 2018b).

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)

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

5.5 Ingestion Stressors

Some of the expended materials resulting from MITT activities are small enough to be ingested by marine mammals, sea turtles, and elasmobranchs. The following expended materials represent potential ingestion stressors for ESA-listed species in the action area: non-explosive practice munitions, fragments of high explosive munitions, target related materials, chaff, and flares.

5.5.1 Non-Explosive Practice Munitions

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

5.5.2 Fragments from High Explosive Munitions

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

5.5.3 Target Related Materials

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

5.5.4 Chaff

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

The chaff concentrations that marine animals could be exposed to following the discharge of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate

because it depends on several variable factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom.

5.5.5 Flares

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

5.6 Secondary Stressors

The proposed action may result in secondary stressors that affect ESA-listed marine mammals, sea turtles, fish, and coral through impacts to species habitat (including water quality or sediments) or prey. Potential secondary stressors include 1) explosives, 2) explosive byproducts and unexploded munitions, 3) metals, 4) chemicals, 5) other materials such as targets, chaff, and plastics; and 6) direct impacts on habitat through physical disturbance.

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 (Navy 2019e). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals.

Chemicals introduced into the marine environment from various Navy training and testing activities 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.

6 SPECIES AND DESIGNATED CRITICAL HABITAT THAT MAY BE AFFECTED

This section identifies the ESA-listed species and designated critical habitat that potentially occur within the action area that may be affected by the proposed action along with their ESA-listing status (Table 52). Section 6.1 then identifies those species not likely to be adversely affected by the proposed action because the effects of the proposed action, evaluated by each stressor, were deemed insignificant, discountable, or wholly beneficial. In Section 6.2, we provide a summary of the biology and ecology in the status of the species and critical habitat sections of those species that may be adversely affected by one or more stressors created by the proposed action, including more detailed information on their life histories in the action area (e.g. environmental baseline), as available.

Table 52. ESA-listed species that may be affected by the proposed action.

Species	ESA Status[1]	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E – 35 FR 18319	-- --	07/1998 10/2018 (draft)
Fin Whale (*Balaenoptera physalus*)	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Humpback Whale (*Megaptera novaeangliae*) – Western North Pacific DPS	E – 81 FR 62259	84 FR 54354* (proposed)	11/1991
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Sea Turtles			
Green Turtle (*Chelonia mydas*) – Central North Pacific DPS	T – 81 FR 20057	-- --	01/1998 U.S. Pacific
Green Turtle (*Chelonia mydas*) – East Indian-West Pacific DPS	T – 81 FR 20057	-- --	01/1998 U.S. Pacific
Green Turtle (*Chelonia mydas*) – Central West Pacific DPS	E – 81 FR 20057	-- --	01/1998 U.S. Pacific

Species	ESA Status[1]	Critical Habitat	Recovery Plan
Hawksbill Turtle (*Eretmochelys imbricata*)	E – 35 FR 8491	63 FR 46693*	05/1998 U.S. Pacific
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710* and 77 FR* 4170	05/1998 U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific DPS	E – 76 FR 58868	-- --	01/1998 - U.S. Pacific
Olive Ridley Turtle (*Lepidochelys olivacea*) All Other Areas/Not Mexico's Pacific Coast Breeding Colonies	T – 43 FR 32800	-- --	01/1998
Fish			
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	9/2018- Outline
Scalloped hammerhead shark (*Sphyrna lewini*) – Indo-West Pacific DPS	T – 79 FR 38213	-- --	-- --
Giant manta ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --
Corals			
Acropora globiceps	T – 79 FR 53851	-- --	-- --
Acropora retusa	T – 79 FR 53851	-- --	-- --
Seriatopora aculeata	T – 79 FR 53851	-- --	-- --

[1] E = endangered, T = threatened

* Critical habitat for this species does not overlap with the MITT Action Area.

6.1 Species Not Likely to be Adversely Affected

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

proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

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

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

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. That means the ESA-listed species may be expected to be affected, but the intensity of the impacts would not reach a scale where take would occur (e.g., harm, harassment).

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species), but it is extremely unlikely to occur[6].

We applied these criteria to the ESA-listed species in Table 52. We summarize our results below for ESA-listed species that are not likely to be adversely affected by any stressor created by the proposed action.

6.1.1 Olive Ridley Sea Turtle

Olive ridley sea turtles are considered a rare species in the MITT Action Area. Sightings are particularly rare in portions of the MITT Action Area located inside the shelf break (e.g., Apra Harbor, Agat Bay, and nearshore waters around Tinian and Saipan) as olive ridley's are primarily an oceanic species. Impacts, if any, would most likely occur to adult olive ridley turtles transiting in offshore waters. Summers et al. (2018a) summarized strandings data (live and dead turtles) between April 2005 and September 2016 on the islands of Saipan and Tinian to obtain baseline information on the primary threats to sea turtles in the CNMI. Of the 89 sea turtle carcasses collected, only one was an olive ridley (juvenile male). Summers et al. (2018a) also reported an anecdotal observation of a juvenile olive ridley entangled in a ghost fishing net in the

[6] When the terms "discountable" or "discountable effects" appear in this opinion, they refer to potential effects that are found to support a "not likely to adversely affect" conclusion because they are extremely unlikely to occur. The use of these terms should not be interpreted as having any meaning inconsistent with our regulatory definition of "effects of the action."

nearshore waters of Rota. Becker et al. (2019) reported sea turtle observations from 13 years of towed-diver surveys across 53 coral islands, atolls, and reefs in the Central, West, and South Pacific, including sites in the Mariana Archipelago. No olive ridley observations were reported in this study across all surveyed sites (green turtles represented 90.1 percent of observations, hawksbills 8.3 percent, and unidentified turtles 1.6 percent). Martin et al. (2018) conducted snorkeling surveys from 2013-2017 in Guam, Saipan, and Tinian (36 total effort days). Out of a total of 375 turtles encountered, none were olive ridleys.

For MITT Phase II, the Navy estimated the olive ridley sea turtle abundance at 0.000001 animals per km^2 for the purposes of modeling effects to species within the action area. The NAEMO predicted zero exposures of olive ridley turtle anticipated to rise to the level of take (≥ 175 dB re 1 μPa rms) as a result of MITT Phase II activities. Due to low levels of occurrence and lack of data, the Navy did not estimate densities for olive ridley turtles in the action area for MITT Phase III. The Navy determined that stressors resulting from sonar and other active acoustic sources, explosives, weapons firing/launch/impact noise, aircraft noise, vessel noise, electromagnetic devices, lasers, vessels and in-water devices, fiber optic cables/wires/parachutes, and military expended materials may affect, but are not likely to adversely affect olive ridley sea turtles due to very low potential for co-ocurrence of individuals and specific stressors that could result in "take." Based on our review of the information available, we concur with the Navy determination that stressors resulting from the proposed action are not likely to adversely affect olive ridley sea turtles.

For the reasons stated above, the effects of Navy stressors on olive ridley sea turtles are considered discountable (i.e., extremely unlikely to occur). We conclude that Navy training and testing activities in the MITT Action Area are not likely to adversely affect olive ridley sea turtles at the individual or population level. Based on our determination that the action is not likely to adversely affect this species, we also conclude that the action is not likely to jeopardize the continued existence of the species. Effects to the species are therefore not considered further in this opinion. No critical habitat has been designated.

6.1.2 *Acropora retusa*

Acropora retusa is distributed from the Red Sea and the Indian Ocean to the central Pacific. Within the Mariana Islands, *Acropora retusa* is confirmed in waters off of Guam, but is not confirmed to occur in CNMI. A recent review of available coral survey data from numerous sites around Guam showed *Acropora retusa* at only one location (off the southwest coastline) where training and testing activities would not occur (Navy 2019e). Several surveys were conducted within Apra Harbor, but the species was not found there (NMFS/PIRO/HCD Guam coral database, 2015). Carilli et al. (2018) found no evidence of *Acropora retusa* in waters surrounding FDM.

As discussed in Section 3.6.2, the Navy proposes to implement mitigation to avoid and minimize impacts to coral reefs. Within the anchor swing circle of shallow-water coral reefs the Navy will

not conduct precision anchoring (except at designated anchorages and nearshore training areas around Guam and within Apra Harbor, where these resources will be avoided to the maximum extent practicable). Within a 350 yd radius of shallow-water coral reefs the Navy will not conduct gunnery, missile, or rocket activities using a surface target; bombing and mine-laying activities; mine countermeasure and neutralization activities; and mine neutralization activities involving Navy divers (except at designated nearshore training areas, where these resources will be avoided to the maximum extent practicable). The Navy will not place mine shapes, anchors, or mooring devices on the seafloor (except in designated locations, where these resources will be avoided to the maximum extent practicable) within a 350 yd radius of shallow-water coral reefs.

In summary, *Acropora retusa* has only been documented in a few locations within the MITT Action Area, and these locations are not areas where Navy activities that could affect this species of coral (e.g., FDM or Apra Harbor) would typically occur. The Navy's proposed procedural mitigation measures to protect coral reefs further reduces the likelihood that this ESA-listed species would be exposed to stressors resulting from MITT activities. Therefore, the likelihood of MITT activities affecting colonies of *Acropora retusa* is so low as to be discountable (i.e., extremely unlikely to occur). We conclude that MITT activities are not likely to adversely affect *Acropora retusa* at the individual or population level. Based on our determination that the action is not likely to adversely affect this species, we also conclude that the action is not likely to jeopardize the continued existence of the species. Effects to the species are therefore not considered further in this opinion. No critical habitat has been designated.

6.1.3 *Seriatopora aculeata*

Seriatopora aculeata is distributed from Australia, Fiji, Indonesia, Japan, Papua New Guinea, and Madagascar to the Marshall Islands. Within the action area, this species is confirmed in Guam and CNMI. On Guam, a recent review of available coral survey data from numerous sites around the island showed *S. aculeata* at two locations. Several surveys were conducted within Apra Harbor, but the species was not found there (NMFS/PIRO/HCD Guam coral database, 2015). In CNMI, coral survey data shows *S. aculeata* on reef slopes at numerous sites around Saipan. Carilli et al. (2018) found no evidence of *S. aculeata* in waters surrounding FDM.

As discussed in Section 3.6.2, the Navy proposes to implement mitigation to avoid and minimize impacts to coral reefs. Within the anchor swing circle of shallow-water coral reefs the Navy will not conduct precision anchoring (except at designated anchorages and nearshore training areas around Guam and within Apra Harbor, where these resources will be avoided to the maximum extent practicable). Within a 350 yd radius of shallow-water coral reefs the Navy will not conduct gunnery, missile, or rocket activities using a surface target; bombing and mine-laying activities; mine countermeasure and neutralization activities; and mine neutralization activities involving Navy divers (except at designated nearshore training areas, where these resources will be avoided to the maximum extent practicable). The Navy will not place mine shapes, anchors,

or mooring devices on the seafloor (except in designated locations, where these resources will be avoided to the maximum extent practicable) within a 350 yd radius of shallow-water coral reefs.

In summary, *Seriatopora aculeata* has only been documented in a few locations within the MITT Action Area, and these locations are not areas where Navy activities that could affect this species of coral (e.g., FDM or Apra Harbor) would typically occur. The Navy's proposed procedural mitigation measures to protect coral reefs further reduces the likelihood that this ESA-listed species would be exposed to stressors resulting from MITT activities. Therefore, the likelihood of MITT activities affecting *Seriatopora aculeata* is so low as to be discountable. (i.e., extremely unlikely to occur). We conclude that MITT activities are not likely to adversely affect *Seriatopora aculeata* and this species, including effects to the species, is not considered further in this opinion. Based on our determination that the action is not likely to adversely affect this species, we also conclude that the action is also not likely to jeopardize the continued existence of the species. No critical habitat has been designated.

6.2 Status of the Species Likely to be Adversely Affected by the Proposed Action

The following ESA-listed species are likely to be adversely affected by the proposed action: blue whale, fin whale, Western North Pacific DPS humpback whale, sei whale, sperm whale, Central West Pacific DPS green sea turtle, Central North Pacific DPS green sea turtle, East Indian-West Pacific DPS green sea turtle, hawksbill sea turtle, leatherback sea turtle, North Pacific DPS loggerhead sea turtle, Indo-West Pacific DPS scalloped hammerhead shark, oceanic whitetip shark, giant manta ray, and *Acropora globiceps*.

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

6.2.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 26). Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and are a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific. The blue whale was originally listed as endangered on December 2, 1970 (35 FR 18319).

Information available from the recovery plan , recent stock assessment reports (Carretta 2019; Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), the status review (NMFS 1998), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

Figure 26. Map identifying the range of the endangered blue whale.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of 10 to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and 15 years of age with an average calving interval of two to three years (COSEWIC 2002; Yochem and Leatherwood 1985). They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed.

Blue whales are highly mobile, and their migratory patterns are not well known (Perry et al. 1999; Reeves et al. 2004). Blue whales migrate toward the warmer waters of the subtropics in fall to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998). Broad scale

movements also varied greatly, likely in response to oceanographic conditions influencing prey abundance and distribution (Bailey et al. 2009). Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (kg) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 m. Blue whales spend more than 94 percent of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5 to 20 times at 12 to 20 sec intervals before a deep dive of 3 to 30 min (Croll et al. 1999a; Leatherwood et al. 1976; Maser et al. 1981; Yochem and Leatherwood 1985).

Vocalizations and Hearing

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

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (20 to 80 Hz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 μPa at 1 m (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004; Cummings and Thompson 1971b; Ketten 1998; McDonald et al. 2001; Samaran et al. 2010). Calling rates of blue whales tend to vary depending on a variety of factors including feeding behavior, diving behavior (more singing during shallow, non-lunging dives), surface behavior (more singular calls), and season (higher rate in autumn than summer) ((Lewis et al. 2018)). For example, blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 m whales), while deeper diving whales (greater than 50 m) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), some variability appears to exist among different geographic areas (Rivers 1997). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005).

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971b; McDonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Mellinger and Clark 2003; Payne and Mcvay 1971). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (McDonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (Leroy et al. 2018; McDonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to approximately 22.5 Hz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have emerged as the probable cause.

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

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

Population Dynamics

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

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

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

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

In general, blue whale distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters off eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east.

They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies (*B. m. intermedia* and B. *m. brevicauda*) seem to be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the "Antarctic Convergence" (located between 48°S and 61°S latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

Blue whales are likely absent from low-productivity tropical waters in the summer. Blue whales are most likely to occur in the MITT Action Area during the winter, although none were observed during the Navy's systematic survey conducted from January to April 2007 (Fulling et al. 2011). No blue whale sightings were reported during NMFS permitted research surveys conducted in Guam and CNMI between 2010 and early 2019 (NMFS Permit Numbers PIFSC 15240, PIFSC 20311, SWFSC 14097, and SWFSC 774-1714). The Pacific Islands Fisheries Science Center (PIFSC) has deployed several passive acoustic monitoring devices to monitor marine mammals and ambient noise levels in U.S. EEZ waters off the Mariana Islands. Blue whales were positively identified at both Saipan and Tinian between 2010–2013, although calls were rare across all years of the study (Oleson et al. 2015). Given the long distance blue whale calls can travel it is not known if the animals were actually within the action area. In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate derived for Hawaiian waters (Bradford et al. 2017) was used to represent the best available estimate for the MITT Action Area. The resulting density estimate of 0.00005 animals/km^2 was used for the MITT Action Area and associated transit corridor for fall, winter, and spring (zero in summer) (Navy 2018e).

Status and Trends

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were harvested from the late nineteenth to mid-twentieth centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965 (Ohsumi and Wada 1972). Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

Estimates of blue whale abundance in the North Pacific are uncertain. Prior to whaling, Gambell (1976) reported there may have been as many as 4,900 blue whales. Blue whales were hunted in the Pacific Ocean, where 5,761 were killed from 1889 to 1965 (Perry et al. 1999). This estimate does not account for under-reporting by Soviet whalers, who took approximately 800 more individuals than were reported (Ivashchenko et al. 2013). The International Whaling Commission (IWC) banned commercial whaling in the North Pacific in 1966, although Soviet

whaling continued after the ban. Although blue whale abundance has likely increased since its protection in 1966, the possibility of unauthorized harvest by Soviet whaling vessel, incidental ship strikes, and gillnet mortalities make this uncertain. Punt (2010) estimated the rate of increase for blue whales in the eastern North Pacific to be 3.2 percent annually (1.4 SE) between 1991 and 2005, while Calambokidis et al. (2009b) estimated a growth rate of three percent annually.

The North Pacific blue whale population structure is unclear and current status unknown, with the exception of a well-studied eastern North Pacific population. The most current information suggests that this portion of the population may have recovered following the cessation of commercial whaling in 1971 and is now nearing the environment's carrying capacity for this species (Monnahan et al. 2015).

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

NMFS developed specific objectives and criteria to recover blue whale populations in a revised draft recovery plan (NMFS 2018c). The two main objectives for blue whales are 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. These threats will be discussed in further detail in the environmental baseline section of this opinion (Section 7). The draft plan establishes criteria for downlisting (to threatened) and delisting based on target minimum abundances for each of the nine identified blue whale management units. For the Western/Central North Pacific management unit occurring in the action area the minimum abundances are 2,000 whales and 2,500 whales for downlisting and delisting, respectively (NMFS 2018c).

6.2.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachonica* (a pygmy form) in the Southern Hemisphere (Figure 27). Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970 (35 FR 18319).

Figure 27. Map identifying the range of the endangered fin whale.

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta 2019; Carretta et al. 2017; Hayes et al. 2017), the status review (NMFS 2011a), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

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

Vocalizations and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Edds 1988; Leroy et al. 2018; Thompson et al. 1992; Watkins 1981a; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). The most typically recorded call is a 20 Hz pulse lasting about one second, and reaching source levels of 189 ±4 dB re: 1 µPa at 1 m (Charif et al. 2002; Clark et al. 2002; Edds 1988; Sirovic et al. 2007; Watkins 1981a; Watkins et al. 1987) (Richardson et al. 1995b). 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. (1995b) 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 1981a; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 Hz call described by Watkins (1981a), was also frequently recorded, although these calls are not as common as the 20 Hz fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, since 40 Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 Hz calls has been reported as 189 ± 5.8 dB re: 1 μPa at 1 m (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981a). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 μPa at 1 m (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-Hz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al. 1992; Watkins et al. 1987). The inter-pulse intervals of these 20 Hz vocalizations increased (.54 seconds/year) and peak frequency decreased (.17 Hz/year) over ten years ((Weirathmueller et al. 2017)).

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

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

Population Dynamics

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

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where NMFS' best estimate of abundance is 1,618 individuals (Nmin=1,234); however, this may be an underrepresentation as the entire range of the stock was not surveyed (Palka 2012). There are three stocks in U.S. Pacific Ocean waters: Northeast Pacific (minimum estimate 1,368 individuals), Hawaii (approximately 154 individuals, minimum estimate 75) and California/Oregon/Washington (approximately 9,029, minimum estimate 8,127) (Bradford et al. 2017; Carretta 2019; Nadeem et al. 2016; NMFS 2019b). The IWC also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

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

Fin whales are typically not expected south of 20°N during summer and are less likely to occur near Guam (Miyashita et al. 1996). Miyashita et al. (1996) presented a compilation of at-sea sighting results by species, from commercial fisheries vessels in the Pacific Ocean from 1964 to 1990. For fin whales in August, Miyashita et al. (1996) reported no sightings south of 20°N, and significantly more sightings north of 40°N. However, they also showed limited search effort south of 20°N. There were no fin whale sightings during the winter 2007 survey of the Action Area (Fulling et al. 2011), nor during Navy-funded monitoring for the MIRC in 2009 through 2013 (HDR 2011a; HDR 2012; Hill et al. 2013; Hill et al. 2011; Ligon et al. 2011; Oleson and Hill 2010). No fin whale sightings were reported during NMFS permitted research surveys conducted in Guam and CNMI between 2010 and early 2019 (NMFS Permit Numbers PIFSC 15240, PIFSC 20311, SWFSC 14097, and SWFSC 774-1714). The PIFSC has deployed several passive acoustic monitoring devices to monitor marine mammals and ambient noise levels in U.S. EEZ waters off the Mariana Islands. Fin whales were positively identified at both Saipan and Tinian between 2010–2013, although calls were rare across all years of the study (Oleson et

al. 2015). The Navy estimated a density of 0.00001 fin whales per km^2 in the MITT Action Area for its Phase III acoustic effects model (Navy 2018e).

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial deoxyribonucleic acid (DNA) genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within 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.

Status and Trends

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whale populations declined, due largely to direct harvest, by more than 70 percent from 1929-2007 (NMFS 2019b). The rough global estimate in 2000 was about 53,000 fin whales. Fin whales may still be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the IWC's ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound.

The species' overall large population size may provide some resilience to current threats, but trends are largely unknown. Population trends for the Southern Hemisphere are lacking and population trends in the North Atlantic are varied, with some unknown trends, increasing trends (e.g., North Central Atlantic) and decreasing trends (e.g., Mediterranean) (NMFS 2019b). In the North Pacific, populations off the U.S. west coast and in Alaskan waters (Kenai Peninsula to Shumagin Islands) are increasing. Although, information is sparse on other demographic parameters, reasonable annual population growth rates have been reported to range from 4-7.5 percent, indicating threats acting on these populations are not limiting growth (NMFS 2019b).

In summary, the 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 2019b). The increasing trend for the large central North Atlantic population and increasing populations in the North Pacific indicate that reproduction is exceeding mortality. Based on result from the latest five-year status review, NMFS has recommended that the fin whale be downlisted from endangered to threatened.

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 goals to recover fin whale populations. These include achieving sufficient and viable populations in all ocean basins and ensuring significant threats are addressed. Threats to fin whales are discussed in further detail in the *Environmental Baseline* section (Section 7) of this opinion. See the 2010 *Recovery Plan for the Fin Whale* (NMFS 2010b) for complete downlisting/delisting criteria for both of the following recovery goals.

6.2.3 Humpback Whale – Western North Pacific Distinct Population Segment (DPS)

The humpback whale is a widely distributed baleen whale found in all major oceans. Humpbacks are typically dark grey with some areas of white, and are distinguishable from other whales by long pectoral fins. The humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central American, and Arabian Sea) and one as threatened (Mexico) (Figure 28) (81 FR 62259). Humpback whales from the endangered Western North Pacific DPS occur in the action area (oval 3 in Figure 28).

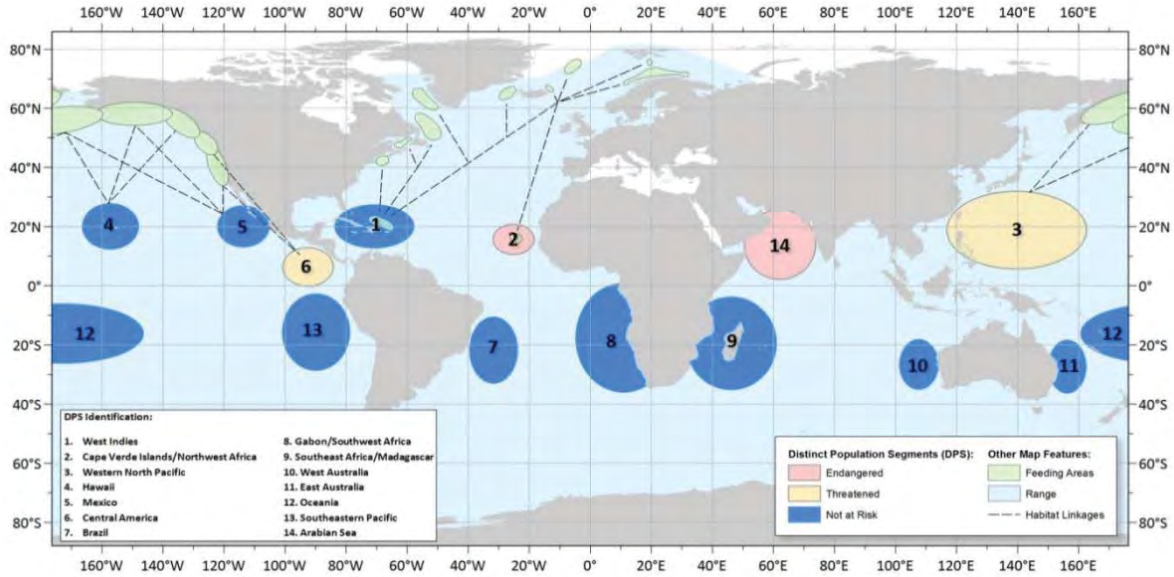


Figure 28. Map identifying 14 DPSs with one threatened and four endangered, based on primary breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015).

Information available from the recovery plan (NMFS 1991), recent stock assessment reports (Carretta 2019; Carretta et al. 2017; Hayes et al. 2017), the status review (Bettridge et al. 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpback whales can live to about fifty years, on average. Gestation takes about 11 months, followed by a nursing period of up to one year (Baraff and Weinrich 1993). Sexual maturity is reached at between 5 to 11 years (e.g., southeast Alaska, Gabriele et al. 2007). Females usually breed every two to three years, although consecutive calving is not unheard of (Clapham and Mayo 1987; 1990; Glockner-Ferrari and Ferrari 1985 as cited in NMFS 2005b; Weinrich et al. 1993). Calving occurs in the shallow coastal waters of continental shelves and oceanic islands (Perry et al. 1999).

During the migration to and from the breeding/calving grounds, adult humpback whales are not feeding and therefore rely on energy stores to fuel the long (8 to 9 month) journey. Pregnant females have been estimated to expend approximately 65 percent of their energy stores during these migrations (Braithwaite et al. 2015). On the migration back to the feeding grounds, females must make frequent stops to nurse their calves. Increases in energy expenditure, therefore, can impact the reproductive success of these animals and their ability to complete the migration cycle before energy stores are depleted.

Adult female humpback whales need an area of refuge where they are undisturbed and able to rest and nurse their young. The time spent on the breeding/calving grounds is a critical period during which neonatal calves must acquire sufficient energy via suckling from their fasting mothers to survive the long return journey. In a study of humpback whale mother-calf pairs on their breeding grounds, Bejder et al. (2019) found lactating humpback whales keep their energy expenditure low by devoting a significant amount of time to rest. Lactating females mainly rest while stationary at shallow depths, often in areas with commercial ships, increasing the potential for ship strike collisions. Even moderate increases of noise, from vessels and other anthropogenic sources, can decrease the time spent resting and can further affect the communication range of humpback whales, including mothers and calves. Videsen et al. (2017) suggests that the small active space of the weak calls between mother and calf is very sensitive to increases in ambient noise from anthropogenic disturbance. An increase in the disturbance level from noise-generating human activities, such as whale watching, shipping and fishing, may increase the risk of mother–calf pair separation, reducing the time available for suckling, or require that louder contact calls are made which, in turn, increases the possibility of detection. Increased ambient noise could have negative consequences for calf fitness (Cartwright and Sullivan 2009; Craig et al. 2014).

Humpbacks exhibit a wide range of foraging behaviors and feed on a range of prey types, including small schooling fish, euphausiids, and other large zooplankton (Bettridge et al. 2015; Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992; Witteveen et al. 2011). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009).

Humpbacks mostly inhabit coastal and continental shelf waters. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Relatively high rates of resighting in foraging sites in suggest humpback whales return to the same areas year after year (Ashe et al. 2013; Kragh Boye et al. 2010). This trend appears to be maternally linked, with offspring returning to the same areas their mother brought them once calves are independent (Baker et al. 2013; Barendse et al. 2013).

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to four kHz with estimated source levels from 144-174 dB (Au et al. 2006; Au et al. 2000b; Frazer and Mercado III 2000; Richardson et al. 1995b; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to ten kHz and having most energy below three kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack 1983). Other social sounds from 50 Hz to ten kHz (most energy below three kHz) are also produced in breeding areas (Richardson et al. 1995b; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to eight kHz but dominant frequencies of 120 Hz to four kHz) which can be very loud (175-192 dB re 1 μPa at 1 m) (Au et al. 2000b; Erbe 2002a; Payne 1985; Richardson et al. 1995b; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995b). Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds only by adult males (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; Smith et al. 2008).

Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark and Clapham 2004; Gabriele and Frankel. 2002; McSweeney et al. 1989). Au et al. (2000a) noted that humpbacks off Hawaii tended to sing louder at night compared to the day. There is geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season, but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne and Mcvay 1971). Components of the song range from below 20 Hz up to four kHz, with source levels measured between 151 and 189 dB re 1

μPa-m and high-frequency harmonics extending beyond 24 kHz (Au et al. 2006; Winn et al. 1970).

Social calls range from 20 Hz to ten kHz, with dominant frequencies below three kHz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986; Simao and Moreira 2005). Female vocalizations appear to be simple; Simão and Moreira (2005) noted little complexity.

Recent data however, suggests that humpback whale songs associated with breeding behaviors are increasingly reported outside of traditional low latitude breeding grounds. Magnusdottir and Lim (2019) analyzed recordings of humpback whale song from Icelandic feeding grounds during January-March 2011 and reported that those songs confirmed the singing of sophisticated songs occur during the breeding season in the subarctic in known summer feeding areas. These areas appear to serve as an important over-wintering area for humpback whales delaying or cancelling their migration – males engage in active sexual displays (i.e., singing) (Magnusdottir and Lim 2019).

Furthermore, evidence supports the use of song as a type of contact call (Darling et al. 2006; Mercado 2018). Darling et al. (2006) supports the hypothesis that song organizes males by providing a real time measure of association between males thereby enabling a means to reciprocate and mutually assist during mating. Additionally, Mercado (2018) suspects that humpbacks use song to detect and travel toward distant whales, like a long range sonar.

“Feeding” calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hz to two kHz, less than one second in duration, and have source levels of 162 to 192 dB re 1 μPa-m (D'Vincent et al. 1985; Thompson et al. 1986). The fundamental frequency of feeding calls is approximately 500 Hz (D’Vincent et al., 1985; Thompson et al., 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic has been documented with archival Digital Acoustic Recording Tags designed to monitor marine mammal behavior and response to sound continuously throughout the dive cycle (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple bouts of broadband click trains that were acoustically different from toothed whale echolocation: Stimpert et al. (2007) termed these sounds “mega-clicks” which showed relatively low received levels at the DTAGs (143 to 154 dB re 1 μPa), with the majority of acoustic energy below two kHz. Recently, Fournet et al. (2018b) analyzed 426 humpback whale calls from Southeast Alaska. Their analysis shows that mean call source level of humpbacks was 137 dB_{rms} re 1 μPa at 1 m in the bandwidth of the call (range 113-157 dB_{rms} re 1 μPa at 1 m), where bandwidth is defined as the frequency range from the lowest to the highest frequency component of the call. These values are robust estimates and demonstrate that earlier estimates of call frequency should be revisited.

Humpback whales rely on acoustic communication to mediate social interactions. The distance to which these social signals propagate from the signaler defines it’s communication space, therefore communication network (number of potential receivers). As humpback whales migrate

along migratory corridors (including coastlines) they are likely to encounter vessel traffic noise from various sources which will mask their social signals. When combined with naturally occurring ambient noise (e.g., wind-dominated) the effect of vessel noise and natural noise can potential reduce the communication space and decrease social interactions among humpbacks during migration (Dunlop 2019). Dunlop (2019) compared the communication space and network of migrating humpback whales in an increasing wind-dominated and vessel-dominated noise environment. They used behavioral data on social interactions to inform their models. Their analyses showed that communication space modeling a wind-dominated noise soundscape was approximately four kilometers and social interactions were reduced to two kilometers. When a vessel-dominated noise soundscape was modelled the communication space was cut in half to one kilometers and social interactions were reduced significantly to one kilometer (Dunlop 2019). Dunlop (2019) suggests that masking was not the only reason for reduced social interactions, the presence of the vessel also was a factor in reduced social interactions.

In another study, Fournet et al. (2018b), using data from Southeast Alaska, also reported that as ambient sound levels (from ships, harbor seals [*Phoca vitulina*], and natural weather events) increased, humpbacks responded by increasing the source levels of their calls (non-song vocalizations) by 0.81 dB (95 percent CI = 0.79-0.90) for every 1 dB increase in ambient sound. Their analyses also found that humpback whale calling decreased by nine percent for every 1 dB increase in ambient sound (Fournet et al. 2018a). Finally, when Fournet et al. (2018b) controlled for ambient sound levels, the probability of a humpback whale calling in the survey area was 31-45 percent lower when vessel noise contributed to the sound scape versus natural sounds.

Houser et al. (2001b) produced a predicted humpback whale audiogram using a mathematical model based on the internal structure of the ear: estimated sensitivity was from 700 Hz to ten kHz, with maximum relative sensitivity between two and six kHz. Research by Au et al. (2001, 2006) off Hawaii indicated the presence of high-frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpbacks can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpbacks to hear frequencies around three kHz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re 1μPa-m or frequency sweep of 3.1to 3.6 kHz (although it should be noted that this system is significantly different from the Navy's hull mounted sonar). In addition, the system had some low frequency components (below one kHz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions. In terms of functional hearing capability, humpback whales belong to the low-frequency cetacean group, which have a hearing range of seven Hz to 35 kHz (NOAA 2016).

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 Western North Pacific humpback whale DPS.

The Western North Pacific DPS consists of humpback whales breeding/wintering in the area of Okinawa and the Philippines, another unidentified breeding area (inferred from sightings of whales in the Aleutian Islands area feeding grounds), and those transiting from the Ogasawara area (Bettridge et al. 2015). The unidentified breeding area corresponds to the historical range for the western North Pacific that includes waters extending from the South China Sea east through the Philippines, the Ryukyu Islands, Mariana Islands, the Marshall Islands and north to the Arctic (Carretta et al. 2017; Muto et al. 2019). Genetic and photographic data collected during Navy-funded small boat surveys has provided matches to individuals identified many years previously off the Ogasawara Islands and the Western North Pacific DPS (Hill et al. 2017). Whales from this DPS migrate to feeding grounds in the northern Pacific, primarily off the Russian coast and Alaska.

Humpback whales have been sighted in the action area in the months of January through March, and male humpback songs have been recorded from December through April. Humpback whale sounds were infrequently detected at Tinian during June to October (Navy 2019e). The detected winter presence of humpbacks in the Mariana Islands is consistent with the Action Area as a plausible migratory destination for humpback whales from Alaska (Carretta et al. 2017; Fulling et al. 2011; Hill et al. 2017; Muto et al. 2019; Oleson et al. 2015).

The presence of newborn calves and competitive groups documented during small boat surveys confirm the Mariana Islands as a breeding location for Western North Pacific DPS humpback whales. Researchers now believe that the Mariana Islands are not only used as a breeding area, but as a winter calving area for humpback whales, as individual females have been recorded returning to the islands. Navy aerial monitoring surveys occurring at FDM conducted monthly from 1997 to 2009, and irregularly thereafter, documented the occasional presence of humpback whales, including mother-calf pairs and other adult individuals (Navy 2019e). Small boat surveys in 2010 and 2014 off Guam, Saipan, Tinian, Aguijan, and Rota did not encounter humpback whales (Hill 2014). Humpback whales were documented in the Mariana Islands from February 26 to March 8, 2015, when four mother/calf pairs and four other individual humpback whales were observed at Chalan Kanoa Reef off Saipan (Hill et al. 2016b). Humpback whales were seen again off Saipan during Navy-funded surveys during January, February, and March of 2016, 2017, and 2018 (Hill et al. 2017; Hill et al. 2018; Hill et al. 2020a; Hill et al. 2020b).

Other areas within the MIRC may support breeding behaviors detected off Saipan. Recently, Munger and Lammers (2020) analyzed Ecological Acoustic Recorder (EARs) data collected during April 2009 to February 2010 off Pagan and data collected from April 2009 to October 2010 off Maug. Humpback whale song was detected at the Pagan EAR on eight days in February

2010, before the EAR stopped recording. No humpback whale song was detected at the Maug EAR and was likely due to the location of the EAR inside the perimeter of the Maug islands (Munger and Lammers 2020). Based on these data, there is a possibility humpback whales may occur within other islands in the archipelago and further investigations are warranted.

Limited systematic sightings data do not allow for a humpback whale density estimation within the action area. In the absence of study-area-specific data, the Navy used a humpback whale density estimate of 0.00089 animals/km^2 derived from a TAIGER NSF survey conducted in waters around Taiwan (LGL 2008; Navy 2019e). This estimate was used to characterize humpback whale density in both the MITT and associated transit corridor study areas for fall, winter, and spring. Humpback whales are likely absent from low-productivity tropical waters in the summer (Jefferson et al. 2008; Perrin et al. 2009); therefore, a density of zero was used for that season.

The current abundance of the Western North Pacific DPS is an estimated 1,107, with a minimum population size estimate of 865 (Muto et al. 2019). A population growth rate is currently unavailable for this DPS. Within the action area, the abundance of humpbacks are estimated to be approximately 938 animals based on extrapolated data from a regional survey off the Phillipines (Acebes et al. 2007).

Status and Trends

It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978). However, from 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whales to roughly 1,000 (Perry et al. 1999). Calambokidis et al. (2008) approximated the size of the whale populations frequenting each breeding area at: 10,000 individuals in Hawaii; 6,000-7,000 animals in the collective areas in Mexican waters; 1,000 for the Western Pacific areas; and 500 for Central America, for a total of 17,500-18,500. For Western North Pacific humpbacks, an annual rate of growth of 6.7 percent was estimated for the years between 1991-1993 and 2004-2006 (Calambokidis et al. 2008). However, this growth rate is considered less robust as sampling effort was significantly greater in the SPLASH study, which may have upwardly biased the western Pacific trend estimate (Calambokidis et al. 2008). Due to this potential bias, the listing final rule to revise the humpback whale listing determined the Western North Pacific DPS has an “unknown” population trend.

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. DPSs that have a total population five hundred individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Populations at low densities (less than one hundred) are more likely to suffer from the ‘Allee’ effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Western

North Pacific DPS is estimated around 1,000 individuals total, and is made up of two subpopulations, Okinawa/Philippines and the Second West Pacific breeding population. Thus, while its genetic diversity may be protected from moderate environmental variance, it could be subject to extinction due to genetic risks due to low abundance (81 FR 62259, Bettridge et al. 2015).

The final rule to revise the humpback ESA listing identified the following threats that may impact the survival and recovery of humpback whales from the Western North Pacific DPS: energy development, competition with fisheries, whaling, entanglement, and vessel collisions (81 FR 62259). All other potential threats identified in the proposed and final rules, including underwater noise from human activities, were considered to have no or minor impact on the population size and/or growth rate, or are unknown, for the Western North Pacific DPS.

Critical Habitat

On October 9, 2019 NMFS proposed designated critical habitat for the Western North Pacific DPS humpback whale (84 FR 54354). The specific occupied areas proposed for designation as critical habitat for this DPS contain approximately 78,690 NM^2 of marine habitat within the North Pacific Ocean, including areas within the Bering Sea and the Gulf of Alaska. The physical and biological features essential to the conservation of the species was described as follows: "Prey species, primarily euphausiids and small pelagic schooling fishes of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth." No critical habitat is designated within the MITT Action Area for the Western North Pacific DPS humpback whale.

Recovery Goals

See the 1991 Humpback Whale Final Recovery Plan for complete down listing/delisting criteria for each of the four following recovery goals:

- Maintain and enhance habitats used by humpback whales currently or historically.
- Identify and reduce direct human-related injury and mortality.
- Measure and monitor key population parameters.
- Improve administration and coordination of recovery program for humpback whales.

6.2.4 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 29). Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011b), recent stock assessment reports (Carretta 2019; Carretta et al. 2017; Hayes et al. 2017), the status review (NMFS 2012), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

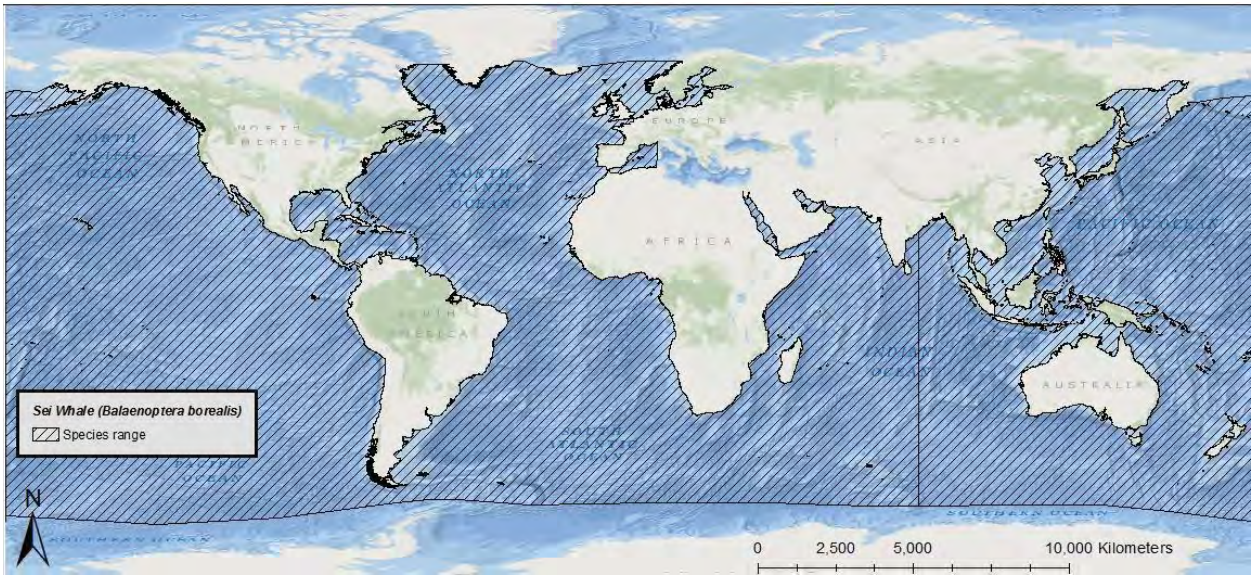


Figure 29. Map identifying the range of the endangered sei whale.

Life History

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

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 Hz to 600 Hz range with 1.5 s duration and tonal and upsweep calls in the 200 Hz to 600 Hz range of one to three seconds durations (McDonald et al. 2005). Differences may exist in vocalizations between ocean basins (Rankin et al. 2009). Recently, (Español-Jiménez et al. 2019) reports vocalizations identified as sei whales from the south-eastern Pacific Ocean recorded during the austral autumn of 2016 and 2017. Calls ranged from an absolute maximum frequency of 129.4 Hz down to an absolute minimum frequency of 30 Hz. Calls recorded during these sessions generally occurred in pairs, but triplets and singles were also recorded. These low-frequency sounds share characteristics with Hawaiian Island sei whales and differ from sounds previously recorded for sei whales in the Southern Ocean (Español-Jiménez et al. 2019).

Vocalizations from the North Atlantic consisted of paired sequences (0.5 to 0.8 sec, separated by 0.4 to 1.0 sec) of 10 to 20 short (4 msec) FM sweeps between 1.5 to 3.5 kHz (Richardson et al.

1995b). Tremblay et al. (2019) reported the occurrence of previously undocumented low frequency (50-34 Hz) triplet and singlet down sweep vocalizations in close association with signature 82 to 34-Hz sei whale vocalizations. These data were collected from an array of bottom-mounted recorders in the western North Atlantic Ocean and later confirmed with spatiotemporal correlations of acoustically tracked sei whales to confirm the origins (Tremblay et al. 2019).

Recordings made in the presence of sei whales have shown that they produce sounds ranging from short, mid-frequency pulse sequences (Knowlton et al. 1991; Thompson et al. 1979) to low frequency broadband calls characteristic of mysticetes (Baumgartner et al. 2008; McDonald et al. 2005; Rankin and Barlow 2007). Off the coast of Nova Scotia, Canada, Knowlton et al. (1991) recorded two-phased calls lasting about 0.5 to 0.8 s and ranging in frequency from 1.5 kHz to 3.5 kHz in the presence of sei whales—data similar to that reported by Thompson et al. (1979). These mid-frequency calls are distinctly different from low-frequency tonal and frequency swept calls recorded in later studies. For example, calls recorded in the Antarctic averaged 0.45 ± 0.3 s in duration at 433 ± 192 Hz, with a maximum source level of 156 ± 3.6 dB re 1 μPa-m (McDonald et al. 2005). During winter months off Hawaii, (Rankin and Barlow 2007) recorded down swept calls by sei whales that exhibited two distinct low frequency ranges of 100 Hz to 44 Hz and 39 Hz to 21 Hz, with the former range usually shorter in duration. Similar sei whale calls were also found near the Gulf of Maine in the northwest Atlantic, ranging from 82.3 Hz to 34.0 Hz and averaging 1.38 s in duration (Baumgartner et al. 2008). These calls were primarily single occurrences, but some double or triple calls were noted as well. It is thought that the difference in call frequency may be functional, with the mid-frequency type serving a reproductive purpose and the low frequency calls aiding in feeding/social communication (McDonald et al. 2005). Sei whales have also been shown to reduce their calling rates near the Gulf of Maine at night, presumably when feeding, and increase them during the day, likely for social activity (Baumgartner and Fratantoni 2008). Off the Mariana Islands, 32 sei whale calls were recorded, 25 of which were backed up by sightings (Norris et al. 2012a). The peak mean frequency of these calls ranged from 890.6 Hz to 1,046.9 Hz with a mean duration of 3.5 to 0.2 seconds. Norris et al. (2012a) reported that simultaneous acoustic detections of called were made from the towed array during three visual sightings.

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. Results of studies on blue whales (Goldbogen et al. 2013; Southall et al. 2011), which have similar auditory physiology compared to sei whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context.

There are no tests or modelling estimates of specific sei whale hearing ranges. To facilitate the acoustic and effects analyses, marine mammals were divided into functional hearing groups (based on their hearing range), and the same criteria and thresholds were used for all species

within a group. For the purposes of this analysis, sei whales were considered part of the low-frequency cetacean group, with a hearing range of 7 Hz to 35 kHz (NOAA 2016).

Population Dynamics

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

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population (excluding the Eastern North Pacific stock) was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (Hakamada et al. 2017). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357, N_{min}=236), Hawaii (N=391, N_{min}=204), and Eastern North Pacific (N=519, N_{min}=374) (Bradford et al. 2017; Carretta 2019). There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. Outside of U.S. waters, a shipboard sighting survey of Icelandic and Faroese waters produced an estimate of about 10,300 sei whales (Cattanach et al. 1993). Additionally in the North Atlantic, Macleod et al. (2005) reported an estimated 1,011 sei whales in waters off Scotland. Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

While some genetic data exist for sei whales, current samples sizes are small limiting our confidence in their estimates of genetic diversity (NMFS 2011b). However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. All stocks of sei whales within U.S. waters are estimated to be below 600 individuals indicating they may be at risk of extinction due to inbreeding.

Various scientists have described the seasonal distribution of sei whales as occurring from 20° N to 23° N during the winter and from 35° N to 50° N during the summer (Horwood 2009; Masaki 1976; Masaki 1977; Smultea et al. 2010). Sei whales were considered to be extralimital in the action area but during the 2007 systematic survey, sei whales were sighted on 16 occasions with a resulting abundance estimate of 166 individuals (CV = 0.49) (Fulling et al. 2011). The 2007 survey indicated this species most often occurs in deep water (10,381 to 30,583 ft. [3,164 to

9,322 m]) within the action area. Most sei whale sightings were also associated with steep bathymetric relief (e.g., steeply sloping areas), including sightings adjacent to the Chamorro Seamounts east of the CNMI (Fulling et al. 2011). All confirmed sightings of sei whales were south of Saipan (approximately 15° N) with concentrations in the southeastern corner of the Action Area (Fulling et al. 2011). Sightings also often occurred in mixed groups with Bryde's whales. Norris et al. (2012a) reported sei whale encounters occurred primarily in the central and southern region of the MITT study area, ranging from the island of Tinian to the southeast corner of the study area. A higher concentration was found in the southeast corner and along the Mariana Trench (Norris et al. 2012a). A sei whale was also detected with sonobuoys on the January to February 2010 Oscar Elton Sette Cruise from Hawaii to Guam. However, the information we have did not allow us to determine if this detection occurred in the MITT Action Area. The Navy's Density Technical Report estimates 0.00029 sei whales per km^2 in the MITT Action Area during spring, fall and winter (Navy 2018e). Sei whales are likely absent from low-productivity tropical waters in the summer.

Status and Trends

The sei whale is endangered as a result of past commercial whaling. Sei whales were estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. No data on the current population trend are available; however, the population in the North Pacific is expected to have increased since sei whales began receiving protection in 1976 (Carretta et al. 2013). However, the possible effects of continued unauthorized takes, vessel strikes, and gillnet mortality make this increasing trend uncertain (Carretta 2019). Barlow (2016) noted that an increase in sei whale abundance observed in 2014 in the California Current is partly due to recovery of the population from commercial whaling, but may also involve distributional shifts in the population.

Critical Habitat

The NMFS has not designated critical habitat for sei whales.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion (Section 7). See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals (NMFS 2011b).

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

6.2.5 Sperm Whale

The sperm whale is widely distributed and found in all major oceans (Figure 30).

Figure 30. Map identifying the range of the endangered sperm whale.

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

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta 2019; Carretta et al. 2017; Hayes et al. 2017), the status review (NMFS 2015c), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

Life History

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

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm

whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between one to six kHz and 10 to 16 kHz. Another class of sound, "squeals," are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 μPa at 1 m, although lower source level energy has been suggested at around 171 dB re: 1 μPa at 1 m (Goold and Jones 1995; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around two to four kHz and 10 to 16 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re: 1 μPa at 1 m (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Miller et al. 2004; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Whitehead and Weilgart 1991). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Laplanche et al. 2005; Miller et al. 2004). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and Whitehead 1997). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Pavan et al. 2000; Weilgart and Whitehead 1997). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008). A recent study by (Gero et al. 2016) using data from nine Caribbean social units (spanning six years) has identified 21 coda types – two of those dominated the repertoires in the population of over 30 years. Results from this study support the social complexity hypothesis in a marine species as different patterns of variation between coda types suggest divergent functions, potentially representing selection for identity signals at several levels of social structure (Gero et al. 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 et al. 1985; Watkins and Schevill 1975). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a ten kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al. 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and one kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA 2016).

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.

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. The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two of three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consist of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288

individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are also available for two of three U.S. stocks that occur in the Pacific, the California/Oregon/ Washington stock, estimated to consist of 1,997 individuals (N_{min}=1,270), and the Hawaii stock, estimated to consist of 4,559 individuals (N_{min}=3,478) (Bradford et al. 2017; Carretta 2019). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time.

Except for waters off the U.S. West Coast, NMFS recognizes two stocks of sperm whales, one in the central Pacific (in Hawaiian waters) and one in the North Pacific (in Alaskan waters) (Carretta 2019; Muto et al. 2019). Sperm whales in the MITT Action Area have not been assigned to a stock. The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 cetacean survey of portions of the Action Area, including sightings of young calves and large bulls (Fulling et al. 2011). These findings are consistent with an earlier sighting of a group of sperm whales that included a newborn calf off the west coast of Guam (Eldredge 2003). Sightings in the action area have included animals close to shore in relatively shallow water as well as in areas near steep bathymetric relief (Fulling et al. 2011; Hill et al. 2017). During the 2007 survey, sperm whales were observed in waters 2,670 to 32,584 ft. (809–9,874 m) deep (Fulling et al. 2011). During a small boat survey around Guam and Saipan in February and early March of 2010, there were two sperm whale sightings: (1) a group of nine animals off Orote Point, Guam, inshore from the 1,640 ft. (500 m) isobath; and (2) a group of six animals northwest of Saipan in waters greater than 3,281 ft. (1,000 m) deep (Ligon et al. 2011). A group of ten sperm whales was also sighted during small boat surveys off western Guam in waters approximately 3,940 ft. deep (1,200 m) in March 2012 (HDR 2012). There were three encounters with sperm whales during the NMFS 2015 cetacean survey of the Mariana Islands (Hill 2018). During the Navy-funded 2010 through 2018 small boat surveys in the Mariana Islands, six sperm whales were encountered on three occasions in a median depth of approximately 1,200 m and median approximate distance from shore of 12 km (Hill 2018; Hill et al. 2017). Line-transect abundance estimates derived from the 2007 survey data yielded an estimate of 705 (CV = 0.60) sperm whales in the action area (Fulling et al. 2011).

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). As none of

the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown.

Status and Trends

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

Critical Habitat

The NMFS has not designated critical habitat for sperm whales.

Recovery Goals

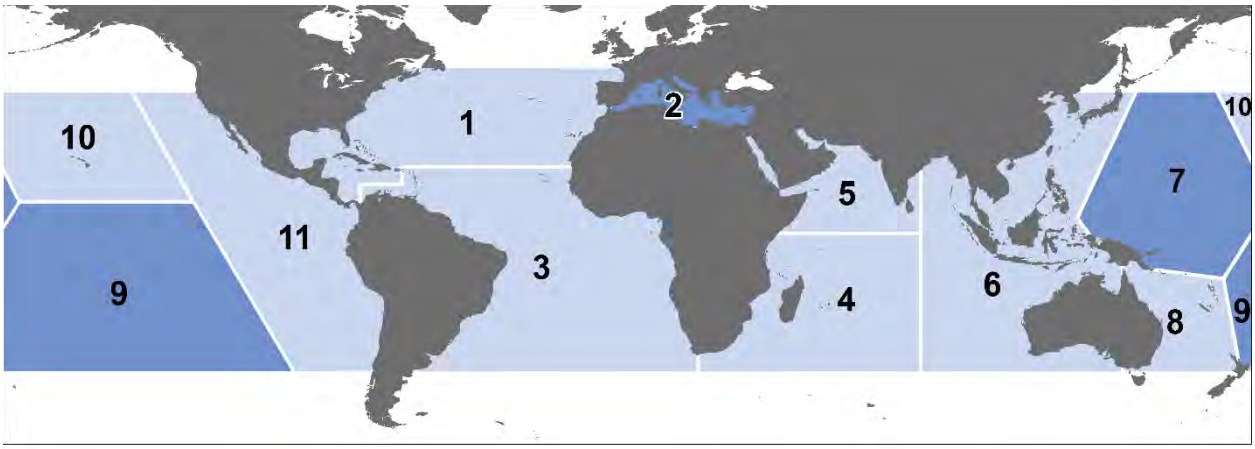
In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion (Section 7). See the 2010 Sperm Whale Final Recovery Plan for complete downlisting/delisting criteria for both of the following recovery goals.

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

6.2.6 Green Sea Turtle

The green sea turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, subtropical and, to a lesser extent, temperate waters (Figure 31). The green sea turtle is the largest of the hardshell marine turtles, growing to a weight of 350 lbs (159 kg) and a straight carapace length (SCL) of greater than 3.3 ft (1 m). The species was listed under the ESA on July 28, 1978. On April 6, 2016, NMFS listed eleven DPSs of green sea turtles as threatened or endangered under the ESA. Eight DPSs are listed as threatened: Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific. Three DPSs are listed as endangered: Central South Pacific, Central West Pacific, and Mediterranean. We expect green sea turtles from three of these DPSs to occur in the MITT Action Area: Central West Pacific, Central North Pacific, and East Indian-West Pacific.

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



Threatened (light blue) and endangered (dark blue) green turtle DPSs:
1. North Atlantic, 2. Mediterranean, 3. South Atlantic, 4. Southwest Indian, 5. North Indian, 6. East Indian-West Pacific, 7. Central West Pacific, 8. Southwest Pacific, 9. Central South Pacific, 10. Central North Pacific, and 11. East Pacific.

Figure 31. Map depicting range and DPS boundaries for green turtles.

Life History

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

Hearing

Sea turtles possess their best hearing range within low-frequency bandwidths, typically hearing frequencies from 30 Hz to 2,000 Hz, with a range of maximum sensitivity between 100 Hz and 800 Hz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found green sea 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). Based upon auditory brainstem responses green sea turtles have been measured to hear in the 50 Hz to 1,600 Hz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have found greatest sensitivities are 200 to 400 Hz for the green turtle with a range of 100 Hz to 500 Hz (Moein Bartol and Ketten 2006;

Ridgway et al. 1969) and around 250 Hz or below for juveniles (Bartol et al. 1999). However, Dow et al. (2008) found best sensitivity between 50 Hz and 400 Hz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 Hz and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3,000 Hz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1,000 Hz and almost no responses beyond 3,000 or 4,000 Hz (Patterson 1966).

Population Dynamics

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

Worldwide, nesting data at 464 sites indicate that around 564,000 females nest each year (Seminoff et al. 2015). Table 53 shows the estimated number of nesting females, nesting sites and the percentage of nesting females at the largest nesting site for each DPS in the action area.

Table 53. Green sea turtle nesting abundance in each DPS (Seminoff et al. 2015).

DPS	Abundance Estimate (nesting females)	Number of Nesting Sites	Largest Nesting Site	Percentage at largest nesting site
East Indian-West Pacific	77,009	58	Wellesley Group, Australia	32%
Central West Pacific	6,518	51	Federated States of Micronesia	22%
Central North Pacific	3,846	13	East Island, French Frigate Shoals, Hawaii	96%

<u>Population Growth Rates</u>

Many nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates for a DPS. Available information on the population growth rates and trends for each of the DPSs is presented below.

East Indian-West Pacific DPS

There are fifty-eight nesting sites for the East Indian-West Pacific DPS, with a total nester abundance estimated at 77,009. The largest nesting site is the Wellesley Group, three islands in the Gulf of Carpentaria off northern Australia. This group hosts thirty-two percent of the nesting females for the DPS (Seminoff et al. 2015).

There are no estimates of population growth for this DPS. There is variation in the nesting abundance trends across nesting sites, with some showing an increase while others are decreasing. Broadly, there is a decrease in nesting females throughout the DPS, with the

exception of Malaysia and the Philippines which showing an increase attributed to successful conservation efforts.

Central West Pacific DPS

This DPS is spatially bounded by the Asian continent to the west and north, the Solomon Islands to the south, the Marshall Islands in the east, and Palau in the west. There are fifty-one nesting sites in the Central West Pacific DPS, with an estimated 6,518 nesting females. The largest nesting site is in the Federated States of Micronesia, which hosts twenty-two percent of the nesting females for the DPS (Seminoff et al. 2015).

Long-term nesting data is lacking for many of the nesting sites in the Central West Pacific DPS, making it difficult to assess population trends. A long-term population time series for this DPS from Chichijima in Ogasawara, Japan showed a positive annual growth rate of 6.8 percent (Seminoff et al. 2015). Martin et al. (2019b) reported mean annual population growth rates for turtles (primarily green sea turtles) around Guam of 8.0 percent (SD = 5.7 percent) since 1963 and 9.3 percent (SD = 3.5 percent) since 1989.

Central North Pacific DPS

There are thirteen known nesting sites for the Central North Pacific DPS, with an estimated 3,846 nesting females. This DPS is very thoroughly monitored, and it is believed there is little chance that there are undocumented nesting sites. The largest nesting site is at French Frigate Shoals, Hawaii, which hosts ninety-six percent of the nesting females for the DPS (Seminoff et al. 2015). Nesting surveys have been conducted since 1973 for green turtles in the Central North Pacific DPS. Nesting abundance at East Island, French Frigate Shoals increases at a rate of 4.8 percent annually.

Genetic Diversity

Available information on the genetic diversity for each of the DPS in the action area is summarized below.

East Indian-West Pacific DPS

Genetic studies have been conducted on around twenty-two of fifty-eight rookeries in the East Indian-West Pacific DPS, revealing a complex population structure. Sixteen regional genetic stocks have been identified, with a few common and widespread haplotypes throughout the region. Rare or unique haplotypes are present at most rookeries (Seminoff et al. 2015).

Central West Pacific DPS

The Central West Pacific DPS is made up of insular rookeries separated by broad geographic distances. Rookeries that are more than 1,000 km apart are significantly differentiated, while rookeries 500 km apart are not (Seminoff et al. 2015). Mitochondrial deoxyribonucleic acid (or DNA) analyses suggest that there are at least seven independent stocks in the region (Dutton et al. 2014a).

Central North Pacific DPS

The majority of nesting for the Central North Pacific DPS is centered at one site on French Frigate Shoals, and there is little diversity in nesting areas. Overall, the Central North Pacific DPS has a relatively low level of genetic diversity and stock sub-structuring (Seminoff et al. 2015).

Distribution

The green sea turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than eighty countries. The green sea turtle is distributed in tropical, subtropical, and to a lesser extent, temperate waters.

East Indian-West Pacific DPS

The East Indian-West Pacific DPS green turtle is found in the Indian Ocean from Southeast Asia through Western Australia. The East Indian-West Pacific DPS comprises nesting sites in Northern Australia, Indonesia, Malaysia, Peninsular Malaysia and the Philippine Turtle Islands. The DPS is spread throughout the eastern Indian Ocean, east of Sri Lanka, south to western and northern Australia, Indonesia, Malaysia, and Taiwan, and north to Japan (Figure 32).

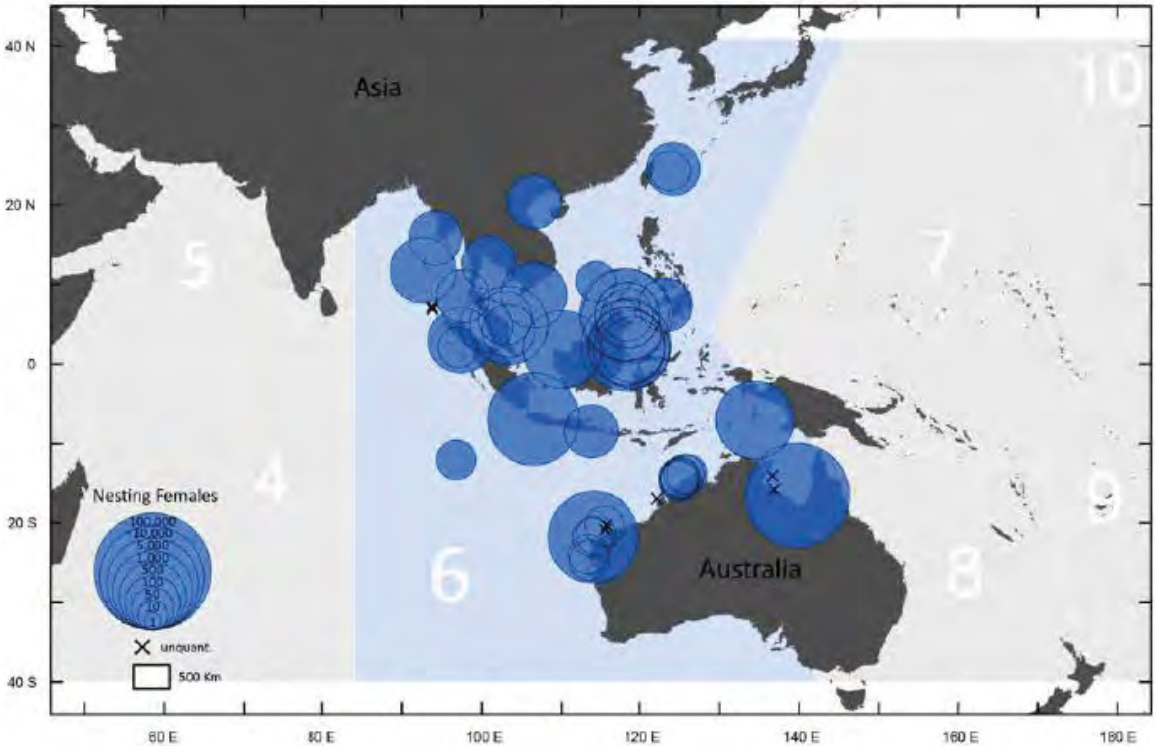


Figure 32. Nesting distribution of green turtles in the East Indian-West Pacific DPS (water body labeled '6'). Size of circles indicates estimated nester

abundance. Locations marked with an 'x' indicate sites lacking abundance information (Seminoff et al. 2015).

Central West Pacific DPS

The Central West Pacific DPS is composed of nesting assemblages in the Federated States of Micronesia, the Japanese islands of Chichijima and Hahajima, the Marshall Islands, and Palau. Green turtles in this DPS are found throughout the western Pacific Ocean, in Indonesia, the Philippines, the Marshall Islands and Papua New Guinea (Figure 33).

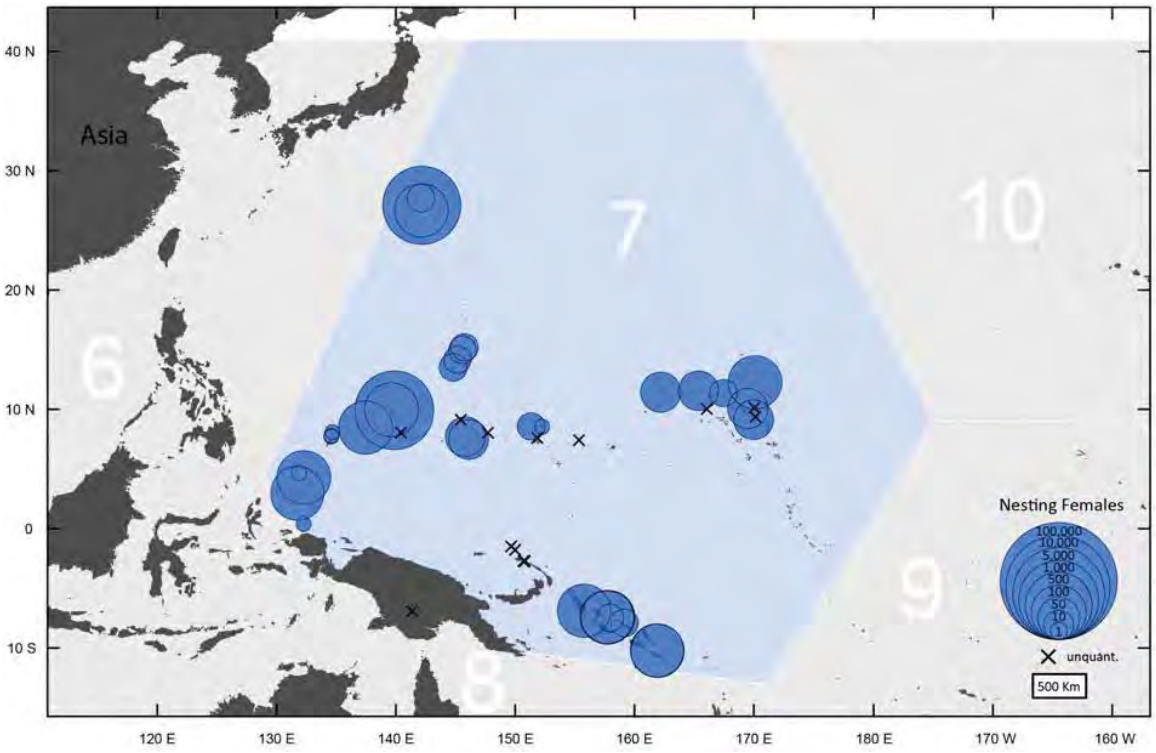


Figure 33. Nesting distribution of green turtles in the Central West Pacific DPS (water body labeled '7'). Size of circles indicates estimated nester abundance. Locations marked with an 'x' indicate sites lacking abundance information (Seminoff et al. 2015).

Central North Pacific DPS

Green turtles in the Central North Pacific DPS are found in the Hawaiian Archipelago and Johnston Atoll. The major nesting site for the DPS is at East Island, French Frigate Shoals, in the Northwestern Hawaiian Islands; lesser nesting sites are found throughout the Northwestern Hawaiian Islands and the Main Hawaiian Islands (Figure 34).

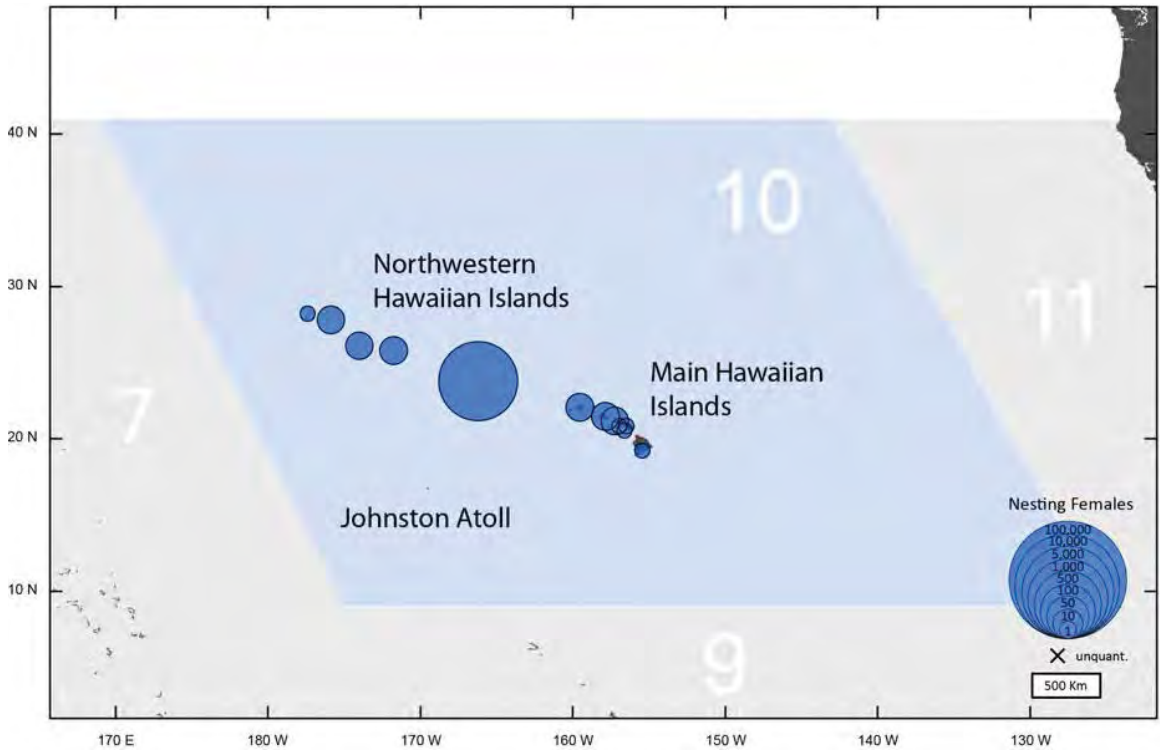


Figure 34. Nesting distribution of green turtles in the Central North Pacific DPS (water body labeled '10'). Size of circles indicates estimated nester abundance (Seminoff et al. 2015).

Occurrence in the MITT Action Area

The majority of green sea turtles in the action area, particularly in nearshore areas, are expected to be from the Central West Pacific DPS (Navy 2019e; NMFS 2017b). Most of the Action Area overlaps with the nesting range of this DPS. Recent genetic analysis suggests that the green turtles may originate from nesting beaches in the Marshall Islands and the Federated States of Micronesia (Dutton et al. 2014b), while a very small percentage (about three percent) are from nesting beaches on French Frigate Shoals, the largest nesting site for the Central North Pacific DPS (NMFS 2017b). There is also some overlap between the far western portion of the Action Area and the nesting range of the East Indian-West Pacific DPS (80 FR 15271; 81 FR 20057). Additionally, the oceanic range of the East Indian-West Pacific DPS may extend further east into other portions of the Action Area where Navy training and testing activities will occur.

Summers et al. (2018b) conducted nesting beach surveys from 2006–2016 on Saipan, Tinian, and Rota. There were 364 total nests observed on Saipan (mean = 36 nests per year), 156 nests on Tinian (mean = 22 nests per year), and 113 on Rota (mean = 16 nests per year. These three islands comprise six percent of the nesting sites for the Central West Pacific DPS overall. Green turtles nest year-round in the CNMI, as documented by observations of nests, hatchlings, and nesting females. Peak nesting occurred between March and July (Summers et al. 2018b). The

CNMI nesting data suggest an annual increase in nesting females of 7.4 percent per year (11 percent without accounting for poaching rates) (Summers et al. 2018b). These results are consistent with a ten percent increase in foraging green turtles (mostly juveniles) estimated from aerial surveys in the southern portion of the Mariana archipelago (Martin et al. 2016). Green turtles have also been documented nesting on many beaches in Guam and the surrounding islands (e.g., (Brindock 2013)), though long-term information regarding nesting population trends in the area are not available.

The CNMI is an important region for settlement and recruitment of juvenile green sea turtles. On Tinian, green turtle abundance and densities are highest along the island's relatively uninhabited east coast. The most recent estimate of the number of green turtles inhabiting the nearshore waters around Tinian was 832 turtles in 2001 (Kolinski et al. 2006) and densities of approximately 11.8 animals per km^2. Between November 2013 and March 2014 the CNMI Department of Lands and Natural Resources captured 54 unique green sea turtles (and three recaptures), 44 around Saipan and ten around Tinian. Catch per unit effort for all sea turtles was 3.75 turtle catches per dive-hour (Palacios et al. 2014). In August 2013, a PIFSC researcher conducted snorkeling and boat surveys off the northwestern coast of Saipan and the western coast of Tinian. The team captured four sub-adult green turtles over a four day period (Jones and Houtan 2014).

Becker et al. (2019) reported sea turtle observations from 13 years of towed-diver surveys across 53 coral islands, atolls, and reefs in the Central, West, and South Pacific, including sites in the Mariana Archipelago (Tinian, Saipan, Guam, Rota, and Aguijan). These surveys covered more than 7,300 linear km, and observed more than 3,000 green sea turtles. The Pacific Remote Island Areas had the highest densities of greens (3.62 turtles km-1, Jarvis Island) and the greatest aggregate predicted abundance of green turtles (219), followed by the Mariana Islands (193). Tinian (392 green turtles per 1000 tow segments) and Saipan (344 green turtles per 1000 tow segments) were more than twice as dense as all other sites within the Mariana Islands sampling area (Becker et al. 2019).

Navy-funded sea turtle tagging occurred off Guam, Saipan, and Tinian from 2013 through 2017. Since August 2013 when tagging began, Martin et al. (2018) report that approximately 94 percent of observed sea turtles that could be identified to species were greens. All but two of the captured green sea turtles were sub-adults or juveniles. The tagged turtles (n=82) showed high site fidelity and limited movements, except for one adult male that traveled over 100 km.

Green turtles are not as abundant around FDM as they are at some of the larger islands of the Marianas chain. At FDM, at least nine green turtles were observed during underwater surveys in both 1999 and 2000, at least 12 green turtles were observed during surveys in 2001, and four were observed at the northern end of the island in 2003 (DoN 2005) . Annual diver surveys between 2005 and 2012 observed between three (2005) and nine (2009) green sea turtles at FDM (DoN 2013). Most green turtles at FDM were found either swimming over the reef platform or

resting in holes or caves (DoN 2005). Due to strong current and tidal conditions, the beaches at FDM are very susceptible to inundation and are highly unsuitable for nesting (DoN 2003a). Also, seagrasses and benthic algae are relatively sparse around the island and can probably support no more than a few green turtles at a time (NMFS and USFWS 1998b). Seven sea turtles were documented in 2006 and 19 in 2007 during monthly monitoring (helicopter surveys) of FDM (DoN 2010b). Monthly observations are usually low (between one and three turtle sightings); however, 12 turtles were observed in waters off FDM on November 13, 2007 (DoN 2010b). Identifying sea turtles to the species level is not possible due to safe flying heights of the helicopter, although due to the higher abundance of green sea turtles relative to hawksbill turtles, the majority of sea turtle observations from these surveys are assumed to be green sea turtles (DoN 2010b).

Aerial surveys conducted by the Guam Division of Aquatic and Wildlife Resources and strandings data indicate the year-round presence of green sea turtles in Guam's nearshore waters (Kolinski et al. 2001; NMFS and USFWS 1998b; Pultz et al. 1999). Aggregations of foraging and resting green turtles are often seen in close proximity to Guam's well-developed seagrass beds and reef flats, which are found in Cocos Lagoon, Apra Harbor, along Tarague Beach and Hila'an; in deeper waters south of Falcona Beach; and at several other locations throughout the island's shelf (DON 2003b; Jones and Houtan 2014). Martin et al. (2016) analyzed long-term trends in sea turtle aerial survey data (1963-2012) from Guam. They estimated that 85 percent of sea turtles in Guam are green turtles, and 15 percent are hawksbills. Martin et al. (2016) reported an eight-fold increase in observed sea turtles (both species combined) on Guam's reefs in the last five decades. However, the dramatic increase was constrained to a single location which contains the Achang Reef Flat Preserve, a no-take MPA established in 1997 and fully enforced by 2001. Turtle observations varied spatially, with the highest densities occurring along the south, east, and north coasts, particularly in areas having low human density, reefs with coral cover, and either seagrass beds or an MPA (or both). Mean green sea turtle abundance estimates for 2008–2012 ranged from 138–299 turtles. A habitat use map for green sea turtles on Guam based on tagging studies is shown in Figure 35 (Navy 2019e).

Based on the above information, green turtles are expected to occur year round in all shelf waters of the Action Area from FDM to Guam. Around the larger islands, green turtle occurrence is concentrated in waters less than 328 ft. (100.01 m) deep, with density estimated at approximately 11.8 animals per km^2 (4.6 mi^2). It is at these water depths where green turtle foraging and resting habitats (e.g., fringing reefs, reef flats, and seagrass beds) are usually found. Although there may not be long-term data available for Guam or CNMI, data from other Pacific regions show that green sea turtles exhibit strong site fidelity to nearshore foraging habitats for extended periods of time (Balazs 1995; Balazs and Chaloupka 2004). Nesting females and early juveniles are known to move through oceanic waters of the Marianas chain during their reproductive and developmental migrations (Kolinski et al. 2006), but likely do not do so in large numbers. Additionally, sea turtles from more distant areas may migrate to the MITT study area to forage.

See Section 2.2.6, Table 8 for the Navy's estimated densities of green sea turtles in the action areas by location and season.

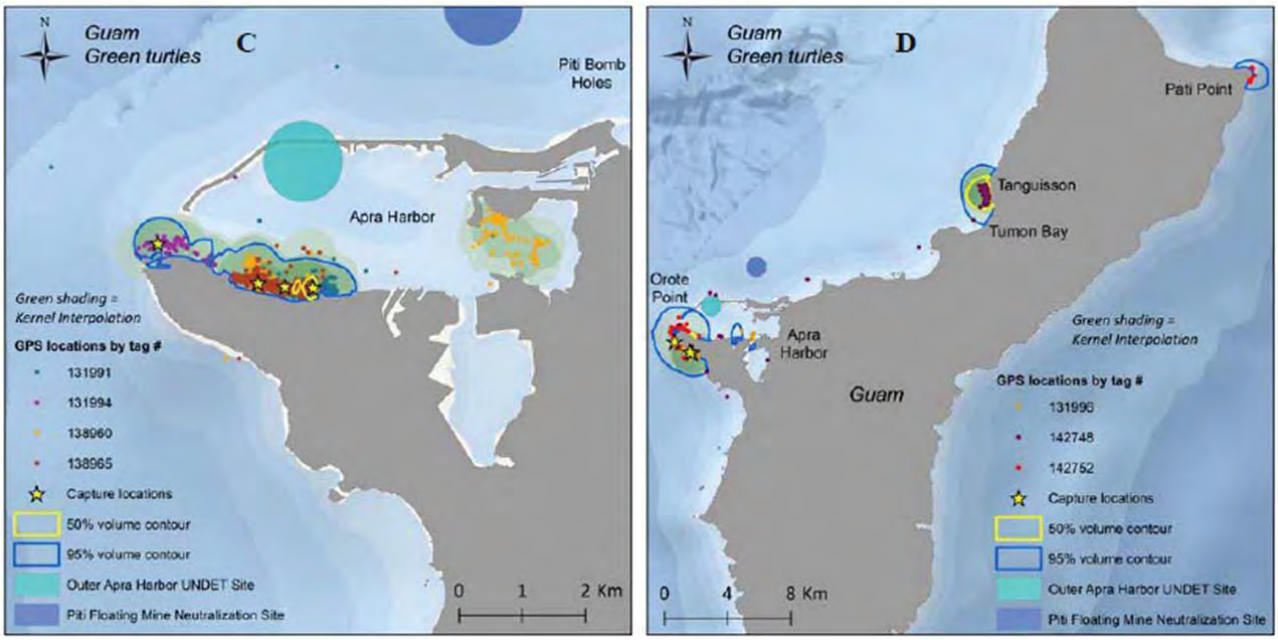


Figure 35. Habitat use map for green sea turtles on Guam (cite Navy BA)

Status and Trends

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

East Indian-West Pacific DPS

The East Indian-West Pacific DPS is relatively large, though it has been reduced from historic levels due to overutilization for commercial and subsistence purposes. Green turtles and their eggs are still harvested for consumption in some areas. Other current threats to the DPS include mortality from incidental bycatch, and predation by feral pigs, dogs and foxes.

Central West Pacific DPS

The Central West Pacific DPS is impacted by incidental bycatch in fishing gear, predation of eggs by ghost crabs and rats, and directed harvest of eggs and nesting females for human consumption. Historically, intentional harvest of eggs from nesting beaches was one of the principal causes for decline, and this practice continues today in many locations. The Central West Pacific DPS has a small number of nesting females and a widespread geographic range. These factors, coupled with the threats facing the DPS and the unknown status of many nesting sites makes the DPS vulnerable to future perturbations. Given the continued hunting pressure in CNMI combined with a very small nesting population, it is reasonable to assume that the continued take of nesting females could further impede recovery of the CNMI component of the Central West Pacific DPS (Seminoff et al. 2015; Summers et al. 2018a).

Central North Pacific DPS

Green turtles in the Hawaiian Archipelago were subjected to hunting pressure for subsistence and commercial trade, which was largely responsible for the decline in the region. Though the practice has been banned, there are still anecdotal reports of harvest. Incidental bycatch in fishing gear, ingestion of marine debris, and the loss of nesting habitat due to sea level rise are current threats to the population. Although these threats persist, the increase in annual nesting abundance, continuous scientific monitoring, legal enforcement and conservation programs are all factors that favor the resiliency of the DPS.

Designated Critical Habitat

No critical habitat has been designated for the green sea turtle DPSs within the action area.

Recovery Goals

See the 1998 and 1991 recovery plans for the Pacific populations of green turtles for complete down-listing/delisting criteria for recovery goals for the species (NMFS and USFWS 1991; NMFS and USFWS 1998b). Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics.

6.2.7 Hawksbill Sea Turtle

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical oceans (Figure 36). The hawksbill sea turtle has a sharp, curved, beak-like mouth and a “tortoiseshell” pattern on its carapace, with radiating streaks of brown, black, and amber. The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973.

We used information available in the 2007 and 2013 five-year reviews (NMFS and USFWS 2007b; NMFS and USFWS 2013a) to summarize the life history, population dynamics and status of the species, as follows.

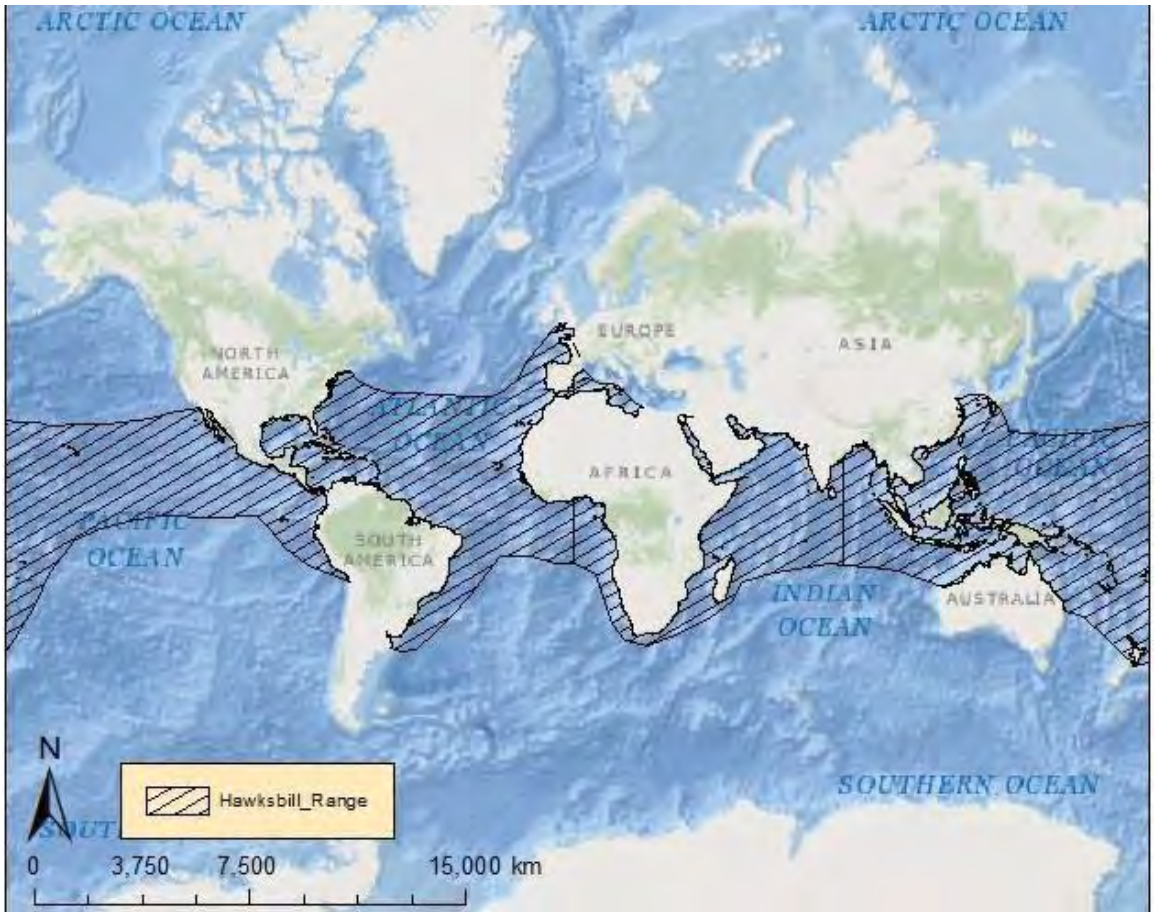


Figure 36. Map identifying the range of the endangered hawksbill sea turtle.

Life History

Hawksbill sea turtles reach sexual maturity at twenty to forty years of age. Females return to their natal beaches every two to five years to nest and nest an average of three to five times per season. Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately 22 to 25 cm in SCL. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbills use their sharp beak-like mouths to feed on sponges and corals. Hawksbill sea turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged turtles have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging locations ranges from a few hundred to a few thousand kilometers (Horrocks et al. 2001; Miller et al. 1998).

Hearing

Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 Hz to 2,000 Hz, with a range of maximum sensitivity between 100 Hz and 800 Hz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found hawksbill hatchlings capable of hearing underwater sounds at frequencies of between 50 and 1,600 Hz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994).

Population Dynamics

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

Surveys at eighty-eight nesting sites worldwide indicate that 22,004 to 29,035 females nest annually (NMFS and USFWS 2013a). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining. From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased fifteen percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2013a). An average of between 11,000 and 12,700 hawksbill nests are estimated to occur each year in the Pacific. Very few hawksbill nests have been seen in the action area. In Guam, only five to ten females are estimated to nest annually (NMFS and USFWS 2013a).

Becker et al. (2019) reported sea turtle observations from 13 years of towed-diver surveys across 53 coral islands, atolls, and reefs in the Central, West, and South Pacific, including sites in the Mariana Archipelago (Tinian, Saipan, Guam, Rota, and Aguijan). These surveys covered more than 7,300 linear km, and observed more than 280 hawksbill sea turtles. American Samoa had the highest reported densities of hawksbills (0.12 turtles per km^2, Ta'u Island) followed closely by the Mariana Islands.

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 sea 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; Monzón-Argüello et al. 2010). Hawksbills in the Caribbean 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 has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile

hawksbills can be found in Sargassum mats; post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997).

In August 2013, a PIFSC researcher and his crew captured two sub-adult hawksbills over a four days survey period off the northwestern coast of Saipan and the western coast of Tinian (Jones and Houtan 2014). Between November 2013 and March 2014 the CNMI Department of Lands and Natural Resources captured three hawksbill sea turtles, two around Tinian and one around Saipan (Palacios et al. 2014).

Navy-funded sea turtle tagging occurred off Guam, Saipan, and Tinian from 2013 through 2017. Since August 2013 when tagging began, Martin et al. (2018) report that approximately six percent of observed sea turtles that could be identified by species were hawksbills. Hawksbill sea turtles made up 12 of 94 satellite tagged individuals. All of the captured turtles were sub-adults or juveniles. The majority of tagged turtles showed high site fidelity and limited movements. However, two hawksbill turtles tagged off Tinian made long-range movements. One traveled 233 km south to the southern coast of Guam where it remained for two years; the other tagged migrated east 2,118 km in 74 days to Ant Atoll adjacent to Pohnpei, Federated States of Micronesia. Overall, the trend data over this time period for sea turtle observations and tagging suggest a dramatic increase in sea turtle populations in waters around Guam, which may indicate increases in hawksbills (Navy 2019e).

Martin et al. (2016) analyzed long-term trends in sea turtle aerial survey data (1963-2012) from Guam. They estimated that 85 percent of sea turtles in Guam are green turtles, and the other 15 percent are hawksbills. Martin et al. (2016) reported an eight-fold increase in observed sea turtles (both species combined) on Guam's reefs in the last five decades. However, the dramatic increase was constrained to a single location which contains the Achang Reef Flat Preserve, a no-take MPA established in 1997 and fully enforced by 2001. Mean hawksbill sea turtle abundance estimates for Guam for 2008–2012 ranged from 101–196 turtles. See Section 2.2.3 for the Navy's estimated densities of hawksbill sea turtles in the action areas by location and season.

Status and Trends

Long-term data on the hawksbill sea turtle indicate that sixty-three sites have declined over the past twenty to one hundred years (historic trends are unknown for the remaining twenty-five sites). Recently, twenty-eight sites (sixty-eight percent) have experienced nesting declines, ten have experienced increases, three have remained stable, and forty-seven have unknown trends. The greatest threats to hawksbill sea turtles are overharvesting of turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbills 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 one hundred percent in some areas. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of

nesting adults. The species' resilience to additional perturbation is low. The continued directed take of juvenile hawksbills in the action area has the potential to negatively impact local populations (Summers et al. 2018a) given the species' imperiled status in CNMI (Summers et al. 2017).

Critical Habitat

On September 2, 1998, the NMFS established critical habitat for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico (63 FR 46693). Aspects of these areas that are important for hawksbill sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill sea turtle prey. No critical habitat is designated within the MITT Action Area for this species.

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 1998c) 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 the Recovery Plans:

1. Identify important nesting beaches
2. Ensure long-term protection and management of important nesting beaches
3. Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters
4. Identify important marine habitats; protect and manage populations in marine habitat
5. Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion
6. Prevent the degradation of reef habitat caused by sewage and other pollutants
7. Monitor nesting activity on important nesting beaches with standardized index surveys
8. Evaluate nest success and implement appropriate nest-protection on important nesting beaches
9. Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation
10. Determine nesting beach origins for juveniles and subadult populations

6.2.8 Leatherback Sea Turtle

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 37). Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. Leatherback sea turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly. The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973.

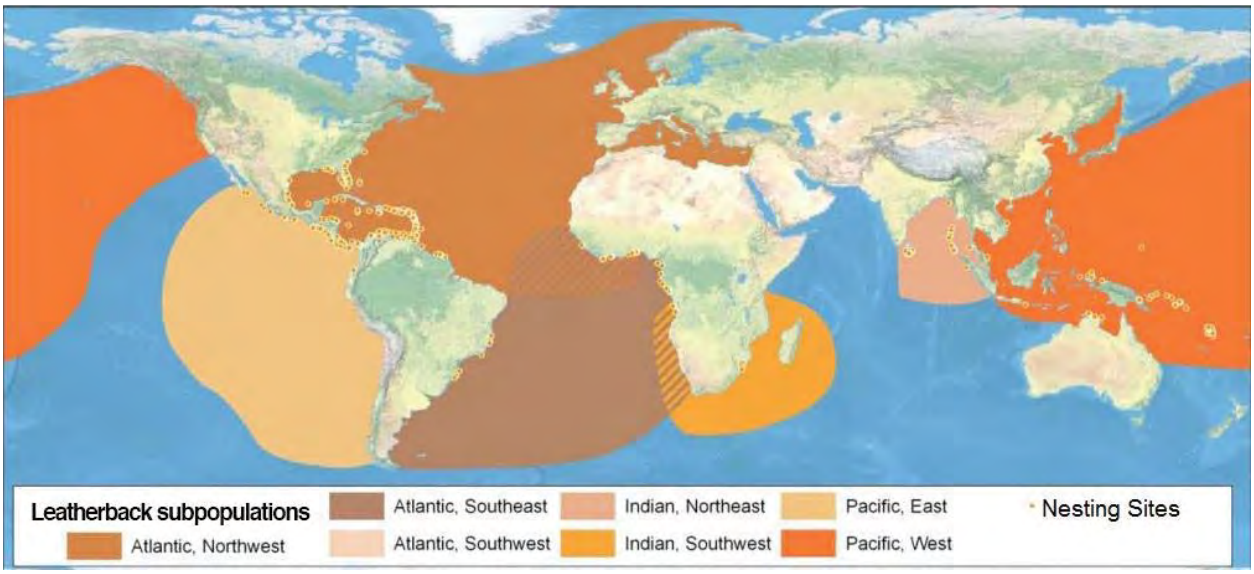


Figure 37. Map identifying the range of the leatherback sea turtle with the seven subpopulations and nesting sites. Adapted from (Wallace et al. 2010).

We used information available in the 2013 five-year review (NMFS and USFWS 2013d) and the critical habitat designations to summarize the life history, population dynamics and status of the species, as follows.

Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to twenty-nine years (Avens et al. 2009; Spotila et al. 1996). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than eighty grams (Reina et al. 2002; Wallace et al. 2007). Leatherback sex determination is affected by nest temperature, with higher temperatures producing a greater proportion of females (Mrosovsky 1994; Witzell et al. 2005). A significant female bias has been reported in several leatherback populations (Binckley et al. 1998; James et al. 2007; Plotkin 1995). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately fifty percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh about thirty-three percent 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; Wallace 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).

Hearing

Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found leatherback hatchlings capable of hearing underwater sounds at frequencies of 50 to 1,200 Hz (maximum sensitivity at 100 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994).

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

Population Dynamics

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

Leatherbacks are globally distributed, with nesting beaches in the Pacific, Atlantic, and Indian oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Pacific leatherbacks are split into western and eastern Pacific subpopulations based on their distribution and biological and genetic characteristics. Only western Pacific leatherbacks are expected to be found within the MITT Action Area.

Most stocks in the Pacific Ocean are faring poorly, as nesting populations there have declined more than 80 percent since 1982 (Sarti-Martinez 2000), while western Atlantic and South African populations are generally stable or increasing (TEWG 2007). Worldwide, the largest nesting populations now occur off of Gabon in equatorial West Africa (5,865 to 20,499 females nesting per year (Witt et al. 2009), in the western Atlantic in French Guiana (4,500 to 7,500 females nesting per year (Dutton et al. 2007) and Trinidad (estimated 6,000 turtles nesting annually (Eckert 2002), and in the western Pacific in West Papua (formerly Irian Jaya), Indonesia (about 600 to 650 females nesting per year (Dutton et al. 2007). By 2004, 203 nesting beaches from 46 countries around the world had been identified (Dutton 2006). Of these, 89 sites (44 percent) have generated data from beach monitoring programs. Although these data are beginning to form a global perspective, unidentified sites likely exist, and incomplete or no data are available for many known sites. Genetic studies have been used to identify two discrete leatherback populations in the Pacific Ocean (Dutton 2006): an eastern Pacific Ocean population, which nests between Mexico and Ecuador; and a western Pacific Ocean population, which nests in numerous countries, including Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu.

There are no known nesting habitats for the leatherback sea turtle in the action area. There are 28 known nesting sites for the western Pacific Ocean stock ranging across the western tropical

Pacific Ocean, from Australia and Melanesia (Papua New Guinea, Solomon Islands, Fiji, and Vanuatu) to Indonesia, Thailand, and China (Chaloupka et al. 2004; Chua 1988; Dutton 2006; Hirth et al. 1993; Suarez et al. 2000). The major nesting populations of the eastern Pacific Ocean stock occur in Mexico, Costa Rica, and Nicaragua (Chaloupka et al. 2004; Dutton et al. 1999; Eckert and Sarti 1997; Márquez 1990; Sarti M. 1996; Spotila et al. 1996), with the largest ones in Mexico and Costa Rica.

Martin et al. (2020) estimated the abundance of western Pacific leatherbacks for the two index beaches in Indonesia, which represent approximately 75% of all nesting individuals. Using the median value for imputed nest counts they estimated 790 total nesters (95% CI: 666–942). Martin et al. (2018) used model-estimated annual female distributions for 2015 to 2017 to estimate an index of current total reproductive female abundance for the western Pacific leatherback population. This was computed as a 3-year run sum based on an assumed 3-year remigration interval. The estimates for 2015-2017 annual females ranged from 340 to 439 and the summed total reproductive female estimate was 1,180 (95% CI: 949–1,479) (Jones et al. 2018). Using this estimate, and assuming a 3:1 ratio of females to males, NMFS (2019a) estimated the current adult portion of the population is 1,851 (1,488-2,320). NMFS (2019a) used the proportion or change in the estimates derived from the information contained in Jones et al. (2018) to estimate the current population size of the West Pacific Ocean leatherback sea turtle. The total West Pacific Ocean population estimate is 175,000 leatherback sea turtles, but may range between 68,000 and 360,000 individuals (NMFS 2019a).

Population growth rates for leatherback sea turtles vary by ocean basin. Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Because the threats to the Pacific leatherback subpopulations have not ceased, the International Union for Conservation of Nature has predicted a decline of 96 percent for the western Pacific subpopulation and a decline of nearly 100 percent for the eastern Pacific subpopulation by 2040, which is only one generation from now (Wallace 2013).

Analyses of mitochondrial DNA from leatherback sea turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian oceans suggest that each of the rookeries represent demographically independent populations (NMFS and USFWS 2013b).

Leatherback sea turtles are distributed in oceans throughout the world. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Leatherback turtles are a highly migratory, pelagic species exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Eckert and Eckert 1988; Eckert 1999). In a single year, a leatherback may swim more than 10,000 km (Eckert 1998). Movements are largely dependent upon reproductive and feeding

cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011). For the western Pacific population, seven ecoregions (South China/Sulu and Sulawesi Seas, Indonesian Seas, East Australian Current Extension, Tasman Front, Kuroshio Extension, equatorial Eastern Pacific, and California Current Extension) were identified as important seasonal foraging areas (Benson et al. 2011).

Leatherbacks sightings in the action area are considered rare, particularly in the nearshore portions (Navy 2019e). This species is occasionally encountered in the deep, pelagic waters of the Marianas archipelago, although only a few occurrence records exist (Eckert et al. 1999). Recent satellite tracking of leatherback turtles indicates sea turtles departing from regional nesting habitats and transiting through the Action Area (Benson et al. 2007). Leatherbacks are not known to nest on any islands within the CNMI or Guam. Eldredge (2003) noted a rescue in 1978 of a 249 lb (112.9 kg) leatherback from waters southeast of Cocos Island, Guam and divers reported seeing leatherbacks in the waters off Harmon Point, Rota from 1987 to 1989. More recent surveys have not reported any leatherbacks in the nearshore portions of the Action Area (Becker et al. 2019; DoN 2010b). Becker et al. (2019) reported sea turtle observations from 13 years of towed-diver surveys across 53 coral islands, atolls, and reefs in the Central, West, and South Pacific, including sites in the Mariana Archipelago (Tinian, Saipan, Guam, Rota, and Aguijan). No leatherback observations were reported in this study across all surveyed sites. Martin et al. (2018) conducted snorkeling surveys from 2013-2017 in Guam, Saipan, and Tinian (36 total effort days). Out of a total of 375 turtles encountered, none were leatherbacks. Since leatherback occurrences in the waters off Guam and the CNMI would most likely involve individuals in transit, occurrence is not expected in coastal (i.e., shelf) waters around any of the islands in the action area. The Navy's Density Technical Report estimates 0.00022 leatherback sea turtles per km^2 in the MITT Action Area (Navy 2018e).

Status and Trends

The leatherback turtle was listed under the Endangered Species Act as endangered throughout its range in 1970. Leatherback sea turtles are endangered by several human activities, including fisheries interactions, entanglement in fishing gear (e.g., gillnets, longlines, lobster pots, weirs), direct harvest, egg collection, the destruction and degradation of nesting and coastal habitat, boat collisions, and ingestion of marine debris.

In the Atlantic, available information indicates that the largest leatherback nesting population occurs in French Guyana, but the trends are unclear. Some Caribbean nesting populations appear to be increasing, but these populations are very small when compared to those that nested in the Pacific less than 10 years ago. Nesting trends on U.S. beaches have been increasing in recent years.

The Pacific Ocean leatherback population is generally smaller in size than that in the Atlantic Ocean. Because adult female leatherbacks frequently nest on different beaches, nesting

population estimates and trends are especially difficult to monitor. In the Pacific, the IUCN notes that most leatherback nesting populations have declined more than 80 percent. In other areas of the leatherback's range, observed declines in nesting populations are not as severe, and some population trends are increasing or stable. Leatherbacks have been in decline in all major Pacific basin rookeries (nesting areas/groups) (NMFS and USFWS 2007c; TEWG 2007) for at least the last two decades (Gilman 2008; Sarti M. 1996; Spotila et al. 1996; Spotila et al. 2000) (Dutton et al. 2007). The IUCN predicted the population is likely to decline by 96% by the year 2040 (e.g., 572 nests, and about 104 females per year nesting, or 260 adult females total [Tiwari et al. 2013; Wallace et al. 2013b, 2013c]). Based on a recent population assessment, Martin et al. (2020) reported a declining trend for western Pacific leatherback sea turtles of −6.1% annually (95% CI: −23.8% to 12.2%).

Causes for this decline include the nearly complete harvest of eggs and high levels of mortality during the 1980s, primarily in the high seas driftnet fishery, which is now banned (Chaloupka et al. 2004; Eckert and Sarti 1997; Sarti M. 1996). With only four major rookeries remaining in the western Pacific Ocean and two in the eastern Pacific Ocean, the Pacific leatherback is at an extremely high risk of extinction. Because only leatherbacks originating from the Western Pacific nesting beaches may be found in the action area, this biological opinion will focus on the effects of the proposed action on the West Pacific population.

Critical Habitat

On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, U.S.V.I. from the 183 m isobath to mean high tide level between 17° 42’12” N and 65° 50’00” W (44 FR 17710). On January 26, 2012, the NMFS designated critical habitat for leatherback sea turtles in waters along Washington State and Oregon (Cape Flattery to Cape Blanco; 64,760 km^2) and California (Point Arena to Point Arguello; 43,798 km^2). The primary constituent element of these areas includes the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora, Aurelia, Phacellophora,* and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks. No critical habitat is designated within the MITT Action Area for this species.

Recovery Goals

See the U.S. Pacific (NMFS and USFWS 1998a) and U.S. Caribbean, Gulf of Mexico and Atlantic Recovery Plans (NMFS and USFWS 1992) for leatherback sea turtles for complete down listing/delisting criteria for each of their respective recovery goals. The top five recovery actions identified in the Leatherback Five Year Action Plan were: 1) Reduce fisheries interactions; 2) Improve nesting beach protection and increase reproductive output; 3) International cooperation; 4) Monitoring and research and 5) Public engagement.

6.2.9 Loggerhead Sea Turtle – North Pacific DPS

Loggerhead sea turtles are circumglobal, and are found in the temperate and tropical regions of the Indian, Pacific and Atlantic Oceans (Figure 38). The loggerhead sea turtle is distinguished from other turtles by its large head and powerful jaws.

The species was first listed as threatened under the ESA in 1978. On September 22, 2011, the NMFS designated nine DPSs of loggerhead sea turtles: South Atlantic Ocean and Southwest Indian Ocean as threatened as well as Mediterranean Sea, North Indian Ocean, North Pacific Ocean, Northeast Atlantic Ocean, Northwest Atlantic Ocean, South Pacific Ocean, and Southeast Indo-Pacific Ocean as endangered. Recent ocean-basin scale genetic analysis supports this conclusion, with additional differentiation apparent based upon nesting beaches (Shamblin et al. 2014). The only loggerhead DPS occurring within the action area, and therefore considered in this biological opinion, is the North Pacific DPS.

We used information available in the 2009 status review (Conant et al. 2009), the final listing rule (76 FR 58868), and the 2020 North Pacific DPS five-year review (NMFS and USFWS 2020b) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Mean age at first reproduction for female loggerhead sea turtles is 30 years (SD = 5). Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average remigration interval is 2.7 years. Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the turtle during the middle of the incubation period. Turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerheads. Multiple foraging strategies at juvenile and adults life stages indicate the importance of several different habitat types and locations to the DPS.

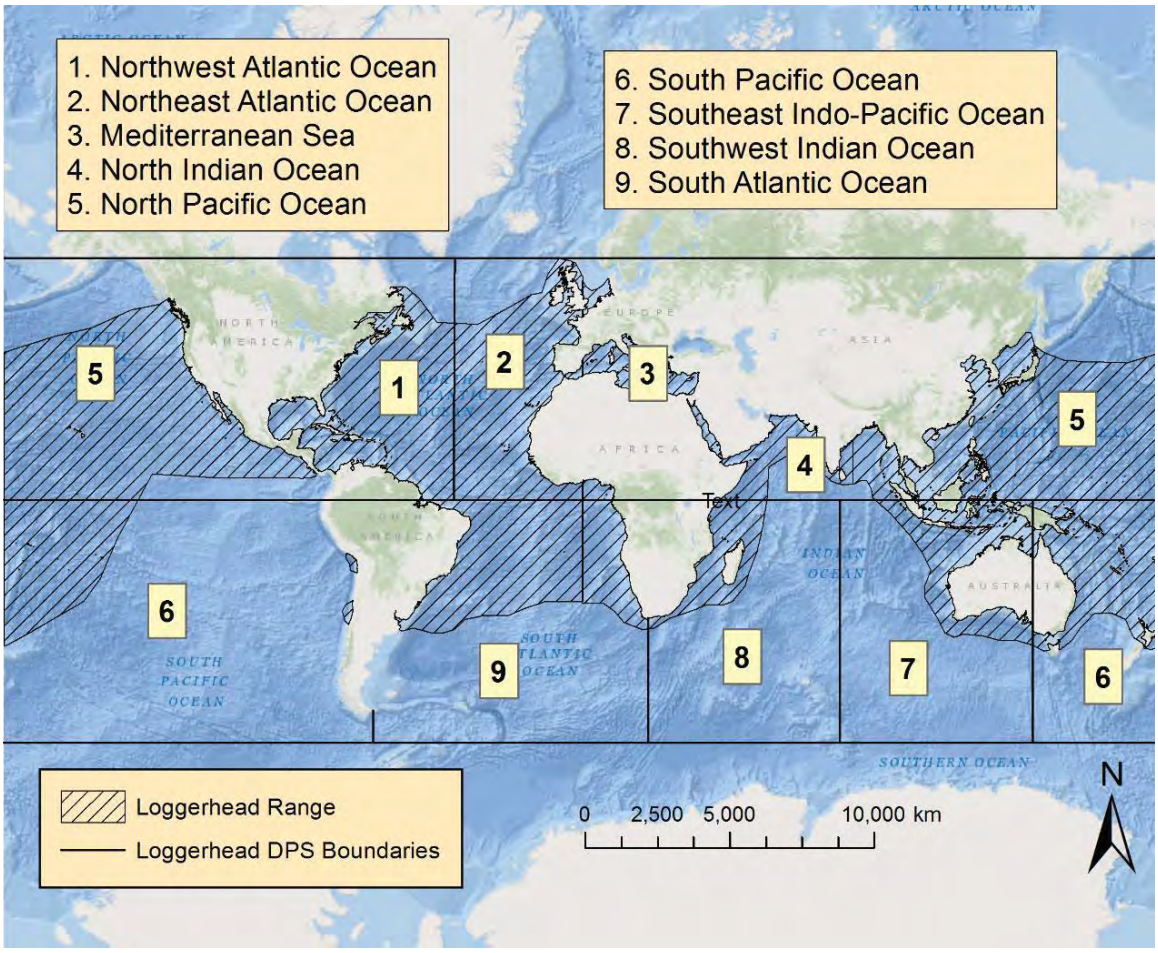


Figure 38. Map identifying the range and DPS boundaries of the loggerhead sea turtle.

Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to two kHz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999) reported effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: 1 μPa and two-year olds: about 86 dB re: 1 μPa), with threshold increasing rapidly above and below that frequency (Moein 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 μPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to one kHz. Post-hatchlings had the

greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

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

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 loggerhead sea turtle.

Loggerhead abundance on foraging grounds off the Pacific Coast of the Baja California Peninsula, Mexico, was estimated to be 43,226 individuals (Seminoff et al. 2014). Gilman (2009) estimated that the number of loggerheads nesting in the Pacific declined by eighty percent in the twenty years prior to this study. There was a steep (fifty to ninety percent) decline in the annual nesting population in Japan during the last half of the twentieth century (Kamezaki et al. 2003).

Based on more recent information, the North Pacific Ocean DPS exhibits: low abundance (an estimated 8,733 nesting females); recently (i.e., less than one generation) increasing population growth (2.3 percent annually); and average demographic characteristics for the species (with the exception of low return rates for nesting females) (NMFS and USFWS 2020b). Martin et al. (2020) evaluated nesting abundance and trends using nest count data from three nesting beaches for which data were available (Inakahama, Maehama, and Yotsusehama on Yakushima). Based on estimates derived from their trend analysis, they calculated an abundance "snapshot" of 4,541 nesting females using those three beaches in 2015. Because these beaches comprise approximately 52 percent of the total nesting population, the extrapolated 2015 total nesting abundance for the entire DPS is approximately 8,733 nesting females (Martin et al. 2020). Though the 95 percent credible interval surrounding the estimated 2.3 percent positive growth rate is moderately wide (−11.0 to 15.6 percent), the distributions around the model fit and the 2015 modeled abundance estimate are quite narrow, providing relatively high confidence in the positive overall trend between 1999 and 2013. These more recent trend estimates differ from the 2009 Status Review, which concluded that loggerheads of the North Pacific declined in abundance over 18 years, from 1990 to 2007 (Conant et al. 2009).

Population structure in the Pacific is comprised of a northwestern Pacific nesting aggregation in Japan and a smaller southwestern nesting aggregation in Australia and New Caledonia. Genetics of Japanese nesters suggest that this subpopulation is comprised of genetically distinct nesting colonies (Hatase et al. 2002a). Almost all loggerheads in the North Pacific seem to stem from Japanese nesting beaches (Bowen et al. 1995; Resendiz et al. 1998). The fidelity of nesting females to their nesting beach allowed differentiation of these subpopulations and the loss of

nesting at a beach means a significant loss of diversity and the beach is unlikely to be recolonized. Recent mitochondrial DNA analysis using longer sequences has revealed a more complex population sub-structure for the North Pacific DPS. Previously, five haplotypes were present, and now, nine haplotypes have been identified in the North Pacific DPS. This evidence supports the designation of three management units in the North Pacific DPS: 1) the Ryukyu management unit (Okinawa, Okinoerabu, and Amami), 2) Yakushima Island management unit and 3) Mainland management unit (Bousou, Enshu-nada, Shikoku, Kii and Eastern Kyushu) (Matsuzawa et al. 2016). Genetic analysis of loggerheads captured on the feeding grounds of Sanriku, Japan, found only haplotypes present in Japanese rookeries (Nishizawa et al. 2014). NMFS (2017c) found that North Pacific DPS loggerhead genetic diversity is adequate for adaptation by natural selection.

Individuals in the western Pacific also show wide-ranging movements. Loggerheads hatched on beaches in the southwest Pacific have been found to range widely in the southern portion of the basin, with individuals from populations nesting in Australia found as far east as Peruvian coast foraging areas still in the juvenile stage (Boyle et al. 2009). Hatchlings from Japanese nesting beaches use the North Pacific Subtropical Gyre and the Kurishio Extension to migrate to foraging grounds. Two major juvenile foraging areas have been identified in the North Pacific Basin: Central North Pacific and off of Mexico's Baja California Peninsula. Both of these feeding grounds are frequented by individuals from Japanese nesting beaches (Abecassis et al. 2013; Seminoff et al. 2014). Adult loggerheads also reside in oceanic waters off Japan (Hatase et al. 2002b). Habitat use off Japan may further be partitioned by sex and size (Hatase et al. 2002b; Hatase and Sakamoto 2004; Hatase et al. 2002c). Loggerheads returning to Japanese waters seem to migrate along nutrient-rich oceanic fronts (Kobayashi et al. 2008; Nichols et al. 2000; Polovina et al. 2000). Individuals bycaught and satellite tracked in Hawaii longline fisheries show individual movement north and south within a thermal range of 15-25º C, or 28-40º N, with juveniles following the 17 to 20º C isotherm (Kobayashi et al. 2008; Nichols et al. 2000; Polovina et al. 2004). The Transition Zone Chlorophyll Front and Kuroshio Extension Current are likely important foraging areas for juvenile loggerheads (Polovina et al. 2004). The Kuroshio Current off Japan may be significant for juvenile and adult loggerheads as a wintering areas for those individuals not migrating south (Hatase et al. 2002c).

We could not find any records of loggerhead sightings, strandings, or nests around Guam or the CNMI. As a result, loggerhead turtles are considered rare within the action area. The westward flowing North Pacific Equatorial Current, which late juvenile stage loggerheads use when returning to the western Pacific, passes through the Marianas region. Telemetry studies show that loggerheads may transit the Action Area; however, the available data indicate that their preferred habitat is likely north of the Action Area (Navy 2019e). Since loggerhead occurrences in the waters off Guam and the CNMI would most likely involve individuals in transit, occurrence is not expected in coastal (i.e., shelf) waters around any of the islands in the action area. Becker et al. (2019) reported sea turtle observations from 13 years of towed-diver surveys across 53 coral

islands, atolls, and reefs in the Central, West, and South Pacific, including sites in the Mariana Archipelago (Tinian, Saipan, Guam, Rota, and Aguijan). No loggerhead observations were reported in this study across all surveyed sites. Martin et al. (2018) conducted snorkeling surveys from 2013-2017 in Guam, Saipan, and Tinian (36 total effort days). Out of a total of 375 turtles encountered, none were loggerheads. The Navy's Density Technical Report estimates 0.000022 loggerhead sea turtles per km^2 in the MITT Action Area (Navy 2018e).

Status and Trends

Once abundant in tropical and subtropical waters, loggerhead sea turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Small abundance contributes to the extinction risk of the DPS because small populations are more likely than large ones to be extirpated as a result of stochastic events and threats (NMFS and USFWS 2020b). Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of turtles in foraging areas remain the greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net and trawl fisheries kill thousands of loggerhead sea turtles annually. Neritic juveniles and adults in the North Pacific DPS are at risk of mortality from coastal fisheries in Japan and Baja California, Mexico. Increasing coastal development (including beach erosion and re-nourishment, construction, armoring and artificial lighting) resulting in habitat degradation threatens nesting success and hatchling survival. Based on these threats and the relatively small population size, the Biological Review Team concluded that the North Pacific DPS was at risk of extinction (Conant et al. 2009). The 2020 five-year review found that the status of the DPS has not changed since it was listed as endangered in 2011 (NMFS and USFWS 2020b). The DPS continues to be endangered by intense (fisheries bycatch and climate change) and numerous (habitat loss and modification, overutilization, and predation) threats acting on a small, subdivided population (NMFS and USFWS 2020b). Although increasing, NMFS (2017c) conclude that its low abundance places it at risk of extinction now (rather than in the foreseeable future).

Critical Habitat

No critical habitat has been designated for the loggerhead North Pacific DPS.

Recovery Goals

Key recovery actions identified in the 1998 Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle are:

1. Reduce incidental capture of loggerheads by coastal and high seas commercial fishing operations.
2. Establish bilateral agreements with Japan and Mexico to support their efforts to census and monitor loggerhead populations and to minimize impacts of coastal development and fisheries on loggerhead stocks.
3. Identify stock home ranges using DNA analysis.

4. Determine population size and status (in U.S. jurisdiction) through regular aerial or on-water surveys.
5. Identify and protect primary foraging areas for the species.

6.2.10 Scalloped Hammerhead Shark – Indo-West Pacific DPS

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.

Scalloped hammerheads are moderately large coastal pelagic sharks found worldwide in coastal warm temperate and tropical seas in the Atlantic, Pacific and Indian Oceans between 46°N and 36°S (Miller et al. 2014a). Four scalloped hammerhead shark DPSs were listed in July 2014: Eastern Pacific DPS and Eastern Atlantic DPS (entirely foreign) were listed as endangered and the Central and Southwest Atlantic DPS and Indo-West Pacific DPS were listed as threatened. Only the Indo-West Pacific DPS overlaps with the Action Area (Figure 39).

Life History

The scalloped hammerhead shark gives birth to live young (i.e., "viviparous"), with a gestation period of 9 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 6.5 to 8 ft (2.0 to 2.5 m) TL, while males reach maturity at smaller sizes (range 4 to 6.5 ft [1.3 to 2.0 m] TL). The age at maturity differs by region. For example, in the Gulf of Mexico, Branstetter (1987) estimated that females mature at about 15 years of age and males at around nine to ten years of age. In northeastern Taiwan, Chen et al. (1990) calculated age at maturity to be four years for females and 3.8 years for males. On the east coast of South Africa, age at sexual maturity for females was estimated at 11 years (Dudley and Simpfendorfer 2006). Parturition, however, does not appear to vary by region and may be partially seasonal (Harry et al. 2011), with neonates present year round but with abundance peaking during the spring and summer months (Adams and Paperno 2007; Duncan and Holland 2006; Harry et al. 2011; Noriega et al. 2011). Females move inshore to birth, with litter sizes anywhere between one and 41 live pups. Off the coast of northeastern Australia, Noriega et al. (2011) found a positive correlation between litter size and female shark length for scalloped hammerheads, 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 one and two feet (0.3 to 0.6 m) TL.

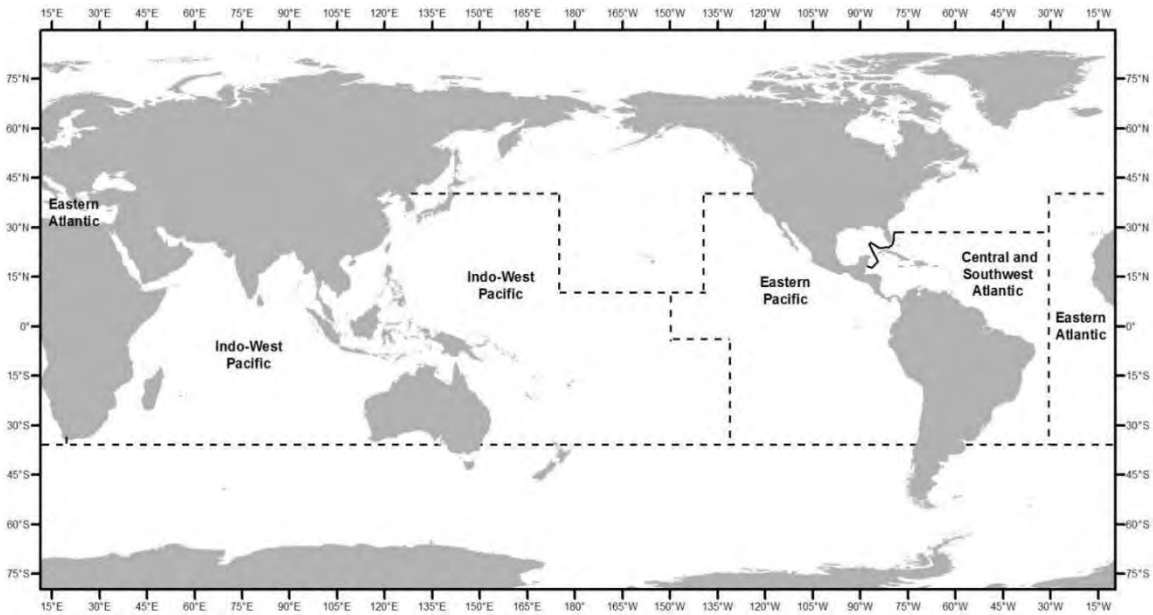


Figure 39. Map depicting the DPSs for the scalloped hammerhead shark.

Scalloped hammerheads are found over continental shelves and the shelves surrounding islands, as well as adjacent deep waters, but are seldom found in waters cooler than 22 degrees 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). Scalloped hammerheads 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). Scalloped hammerheads are high trophic level, opportunistic predators whose diet includes crustaceans, fish and cephalopods.

Hearing

Scalloped hammerhead sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Myrberg 2001; 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 fish, including scalloped hammerheads, suggest they can detect sound between 20 Hz to one kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Ladich and Fay 2013; Myrberg 1978; Myrberg 2001; Olla 1962). A study involving unidentified hammerhead sharks of the genus *Sphyrna*, indicates attraction to low frequency sound between 20 and 60 Hz (Nelson

and Gruber 1963). However, a study specifically on scalloped hammerheads found no attraction to similar low frequency sound (Klimley and Nelson. 1981).

Population Dynamics

Based on information related to genetic variation among populations, behavior and physical factors, and differences in international regulatory mechanisms, the scalloped hammerhead Extinction Risk Analysis team identified six DPSs: Northwest Atlantic and Gulf of Mexico; Central and Southwest Atlantic; Eastern Atlantic; Indo-West Pacific; Central Pacific; and Eastern Pacific (Miller et al. 2014a).

The Indo-West Pacific DPS range covers a very large area and abundance estimates for the entire DPS are unavailable. However, documented trends in abundance in particular areas suggest significant depletions of local populations. Data collected from East Lombok, Indonesia, suggest potential population declines as the proportion of scalloped hammerheads in the Tanjung Luar artisanal longline fishery catch decreased from 15 percent to two percent from 2001 to 2011. Scalloped hammerhead sharks off the coast of South Africa are also thought to be experiencing similar decreases in population size. Analyses of fishery-independent data from beach protection programs have revealed drastic declines in catch rates since the early 1950s. From 1952-1972, Ferretti et al. (2010) estimated a decline of 99.3 percent in scalloped hammerhead catch rates off Main Beach in South Africa, and a decline of 86 percent from 1961-1972 off Brighton Beach, South Africa. Estimates of the decline in hammerhead abundance in Australia's northwest marine region, based on analysis of catch-per-unit-effort data from 1996-2005, range from 58-76 percent (Heupel and McAuley 2007). Data from protective shark meshing programs off beaches in New South Wales and Queensland also suggest significant declines in hammerhead populations off the east coast of Australia. Over a 35 year period, the number of hammerheads caught per year in beach protection nets has decreased by more than 90 percent, from over 300 individuals in 1973 to less than 30 in 2008 (Reid and Krogh 1992). Similarly, data from the Queensland shark control program indicates a 63 percent decline in scalloped hammerhead shark abundance between 2005 and 2010 (QPIF 2011).

Scalloped hammerhead sharks primarily occur over continental and insular shelves, ranging from surface waters to depths of 512 m with occasional dives to deeper water up to 1000 m. Scalloped hammerhead sharks appear to prefer areas with strong currents, high turbidity, and high sedimentation and nutrient flow. Based on a satellite tagging study in the Gulf of Mexico, Wells et al. (2018) found habitat suitability for scalloped hammerheads was predicted to be high on the mid to outer continental shelf inside the 200 m isobath. Model results highlighted the use of continental shelf waters with high occurrence at close proximities to both artificial and hard-bottom habitat combined with low chlorophyll a concentrations (~ 0–4 mg m-3) and moderate salinities (33–35.5). Scalloped hammerheads are also known to occur in bays and estuaries.

In a study of tagged scalloped hammerheads in the Eastern Tropical Pacific, Nalesso et al. (2019) found that oceanic islands and seamounts represent important habitat for this species. Scalloped

hammerheads formed large aggregations at several locations around Cocos Island, similar to Galapagos, Malpelo and other oceanic islands in the Eastern Tropical Pacific. Results of this study suggest that these aggregations are fluid, such that individuals do not remain at the island constantly throughout the year, but rather associate with the island mostly during daytime hours, and returned to the same island after absences of nine months or greater (Nalesso et al. 2019).

There is very little information on the occurrence, distribution, or use of habitat by the scalloped hammerhead shark within Guam and the CNMI. In Guam, anecdotal reports suggest that Apra Harbor may serve as a pupping ground for scalloped hammerhead sharks, based on the observed presence of young scalloped hammerhead sharks in Sasa Bay and Inner Apra Harbor (Miller et al. 2014a; NMFS 2015a). Over the time period of 1982-2004, a NMFS scientist working in Guam indicated that he personally observed and caught juvenile and adult scalloped hammerhead sharks in Apra Harbor (specifically the channel that connects the inner harbor and Sasa Bay) and observed juveniles near northern Piti, the Pago Bay river mouth, and the Ylig River mouth, and adults outside of Pago Bay and Tarague Beach (NMFS 2015a).

Status and Trends

Based on a combination of fisheries dependent and fisheries independent data, it is estimated that hammerhead shark populations have experienced drastic population declines, in excess of 90 percent, in several parts of their global range (Gallagher et al. 2014). The primary factors responsible for the decline of the ESA-listed scalloped hammerhead DPSs are overutilization, due to both catch and bycatch of these sharks in fisheries, and inadequate regulatory mechanisms for protecting these sharks, with illegal fishing identified as a significant problem (Miller et al. 2014a). Evidence of heavy fishing pressure by industrial, commercial and artisanal fisheries, reports of significant illegal, unreported, unregulated fishing, especially off the coast of Australia, and high at-vessel mortality rates have likely led to overutilization of the Indo-West Pacific DPS. Coupled with inadequate regulatory measures, especially in the Western Indian Ocean and Indonesian waters, and habitat degradation, the present and future threats facing this DPS indicate it is approaching a level of abundance and productivity that places its current and future persistence in question (Miller et al. 2014a).

Hammerhead sharks are afforded some protections from overharvesting within the action area (Miller and Klimovich 2017). The Micronesia Regional Shark Sanctuary Declaration, which includes the EEZs of Guam and CNMI, prohibits possession, sale, distribution and trade of sharks and rays and shark and ray parts (with some exemptions for research and subsistence fishing). Illegal harvest is likely still a problem given the large area and limited enforcement available.

Designated Critical Habitat

No critical habitat has been designated for the scalloped hammerhead shark.

Recovery Goals

NMFS has not prepared a recovery plan for the scalloped hammerhead shark.

6.2.11 Giant Manta Ray

The giant manta ray is an elasmobranch species that occupies tropical, subtropical, and temperate oceanic waters and productive coastlines (Figure 40). Giant manta rays have a diamond-shaped body with wing-like pectoral fins measuring up to 25 ft (8 m) across. On January 22, 2018, NMFS published a final rule listing the giant manta ray as threatened under the ESA.

We used information available in the 2017 Status Review (Miller and Klimovich 2017), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

Figure 40. Map depicting the range of the giant manta ray [adapted from Lawson et al. (2017)]

Life History

Giant manta rays reach sexual maturity at about ten years old. They are viviparous, giving birth to one pup every two to three years. Gestation lasts between 12 to 13 months. Giant manta rays can live up to 40 years, so a female may only produce between five to 15 pups in a lifetime (FAO 2012).

Giant manta rays are migratory, capable of undertaking migrations up to 1,500 km (Graham et al. 2012; Hearn et al. 2014), although some tagged individuals have been observed staying in the same location (Stewart et al. 2016). Giant manta rays have been observed in aggregations of 100 to 1,000 individuals (Miller and Klimovich 2017; Notarbartolo-di-Sciara and Hillyer 1989), at particular sites. These sites are thought to be feeding or cleaning locations, or where courtships take place.

Giant manta rays are planktivores, using gill plates (also known as gill rakers) to feed on zooplankton. They conduct night descents to between 200 and 450 m, and can even dive to

depths of over 1,000 m. During the day, they can also be found feeding in shallow waters (less than 10 m) (Miller and Klimovich 2017).

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 fish suggest they can detect sound between 20 Hz to one kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Ladich and Fay 2013; Myrberg 2001).

Population Dynamics

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

There are no current or historical estimates of range-wide giant manta ray abundance, although there are some rough estimates of subpopulation size based on anecdotal accounts from fishermen and divers. It is difficult to obtain reliable abundance estimates as the species is only sporadically observed. There are about 11 subpopulation estimates worldwide (perhaps more), and these subpopulation estimates range from 100 to 1,500 individuals each (FAO 2012; Miller and Klimovich 2017).

There is not a great deal of information on the population structure of giant manta ray. Some evidence suggests that there are isolated subpopulations (Stewart et al. 2016), and possibly a subspecies resident to the Yucatán (Hinojosa-Alvarez et al. 2016).

Data on population trends globally are largely unavailable. However, there have been decreases in landings of up to 95 percent in the Indo-Pacific, though these declines have not been observed in other subpopulations such as Mozambique and Ecuador (Miller and Klimovich 2017).

Giant manta rays are commonly found offshore in oceanic waters, but are sometimes found in shallow waters (less than 10 m) during the day (Lawson et al. 2017; Miller and Klimovich 2017). We are not aware of any surveys or sightings of giant manta rays in the action area, but based on their life histories and occurrence in other similar environments we would expect to find them there. Martin et al. (2016) analyzed aerial survey data from 1963-2012 of the insular coral reef

ecosystem of Guam (including Apra Harbor). Giant manta rays were not observed over this time span but surveyors did record 60 reef manta rays (*Manta alfredi*).

Status and Trends

The Status Review found that giant manta rays are at risk throughout a significant portion of their range, due in large part to the observed declines in the Indo-Pacific. There are few known natural threats to giant manta rays. Disease and shark attacks were ranked as low risk threats, and giant manta rays exhibit high survival rates after maturity (Miller and Klimovich 2017).

The most significant threat to giant manta ray populations is commercial fishing. Giant manta rays are a targeted species for the mobuild gill raker market. Gills from mobuilds (i.e., rays of the genus *Mobula*, including *Manta* spp.) are dried and sold in Asian dried seafood and traditional Chinese medicine markets (O'Malley et al. 2017). Sources for gill rakers sold in these markets include China, Indonesia, Vietnam, Sri Lanka, and India; one market in Guangzhou, China, accounts for about 99 percent of the total market volume. In 2011, there was an estimated 60.5 tons of mobuild gill rakers, which almost doubled to 120.5 tons in 2015 (O'Malley et al. 2017).

Giant manta rays are afforded some protections from overharvesting within the action area (Miller and Klimovich 2017). The Micronesia Regional Shark Sanctuary Declaration, which includes the EEZs of Guam and CNMI, prohibits possession, sale, distribution and trade of sharks and rays and shark and ray parts (with some exemptions for research and subsistence fishing). Illegal harvest is likely still a problem given the large area and limited enforcement available. Giant manta rays may also be afforded some protection through a Marine Protected Area along the northwest coast of Guam that covers shallow areas with relatively high densities of reef manta rays (Martin et al. 2016).

In addition to the threat from directed fishing, giant manta rays are also captured incidentally in industrial purse seine and artisanal gillnet fisheries. Incidental bycatch is a particular concern in the eastern Pacific Ocean, and the Indo-Pacific (Miller and Klimovich 2017). Given the species' extremely low reproductive output and overall productivity, it is inherently vulnerable to threats that would deplete its abundance, with a low likelihood of recovery (Miller and Klimovich 2017).

Designated Critical Habitat

No critical habitat has been designated for the giant manta ray.

Recovery Goals

NMFS has not prepared a recovery plan for the giant manta ray.

6.2.12 Oceanic Whitetip Shark

The oceanic whitetip shark is distributed worldwide in tropical and subtropical waters between 10° North and 10° South, usually found in open ocean and near the outer continental shelf (Figure 41).

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 kg. The oceanic whitetip shark was listed as threatened under the ESA on January 30, 2018.

We used information available in the 2017 Status Review (Young et al. 2017), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

Life History

The oceanic whitetip shark gives birth to live young (i.e., "viviparous"). Their reproductive cycle is thought to be biennial, giving birth on alternate years, after a lengthy 10 to 12-month gestation period. The number of pups in a litter ranges from one to 14 (mean = 6), and a positive correlation between female size and number of pups per litter has been observed, with larger sharks producing more offspring (Bonfil et al. 2008; IOTC 2014; Seki et al. 1998). Not a great deal is known about oceanic whitetip sharks' lifespan. Estimates range from 12 to 13 years (Lessa et al. 1999; Seki et al. 1998), to 17 years, and even up to 20 years old (Young et al. 2017). They are a slow-growing species, and growth rates are believed to be similar between the sexes (Joung et al. 2016; Lessa et al. 1999; Seki et al. 1998; Young et al. 2017). Age at maturity varies by ocean region, with six to seven years old recorded in the southwest Atlantic, and four to nine years old in the North Pacific, with the sexes having similar ages at maturity (Joung et al. 2016; Lessa et al. 1999; Seki et al. 1998).

Little is known about the movement or possible migration paths of the oceanic whitetip shark. Although the species is considered highly migratory and capable of making long distance movements, tagging data provides evidence that this species also exhibits a high degree of philopatry (i.e., site fidelity) in some locations. In the Atlantic, young oceanic whitetip sharks have been found well offshore along the southeastern coast of the U.S., suggesting that there may be a nursery in oceanic waters over this continental shelf (Bonfil et al. 2008; Compagno 1984). In the southwestern Atlantic, the prevalence of immature sharks, both female and male, in fisheries catch data suggests that this area may serve as potential nursery habitat for the oceanic whitetip shark (Coelho et al. 2009; Frédou et al. 2015; Tambourgi et al. 2013; Tolotti et al. 2015). Juveniles seem to be concentrated in equatorial latitudes, while specimens in other maturational stages are more widespread (Tambourgi et al. 2013). Pregnant females are often found close to shore, particularly around the Caribbean Islands.

Oceanic whitetip sharks are regarded as opportunistic feeders, eating teleosts (bony fish) and cephalopods. Large pelagic fish species commonly found in the stomachs of oceanic whitetips include, blackfin tuna, white marlin, and barracuda.

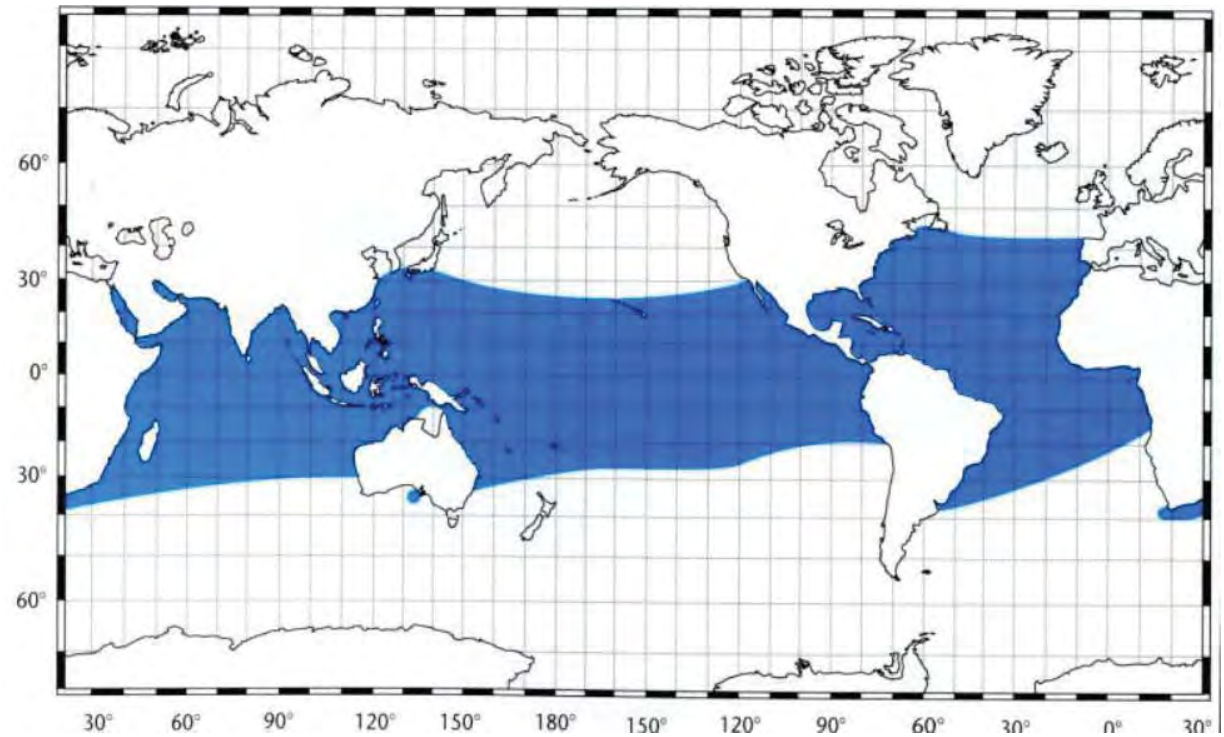


Figure 41. Geographic range of the oceanic whitetip shark [adapted from Last and Stevens (2009)].

Hearing

Oceanic whitetip sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Myrberg 2001; Myrberg et al. 1978; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 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 fish suggest they can detect sound between 20 Hz to one kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Ladich and Fay 2013; Myrberg 2001). Studies involving oceanic whitetip sharks show attraction to low frequency sounds, particularly those between 25 and 50 Hz, with less but still noticeable attraction at higher frequencies between 500 and 1,000 Hz (Myrberg 2001; Myrberg et al. 1975a; Myrberg et al. 1975b; Myrberg et al. 1976; Myrberg et al. 1978).

Population Dynamics

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

There is no range-wide abundance estimate available for oceanic whitetip sharks. However, the species was once one of the most abundant sharks in the ocean. Catch data from individual ocean basins indicate that the populations have undergone significant declines (Young et al. 2017). In the Northwest Atlantic and Gulf of Mexico, declines are estimated to be between 57 and 88 percent (Young et al. 2017). Populations in the Eastern Pacific Ocean are thought to have declined between 80 and 90 percent since the late 1990s (Hall 2013). Although generally not targeted, due to their vertical and horizontal distribution oceanic whitetip sharks are frequently caught as bycatch in many fisheries, including pelagic longline fisheries targeting tuna and swordfish, purse seine, gillnet, and artisanal fisheries. They are also a preferred species for their large, morphologically distinct fins, as they obtain a high price in the Asian fin market.

While there is limited research on the genetic diversity of oceanic whitetip sharks, that which exists indicates low genetic diversity. Compared to other pelagic sharks (e.g., silky sharks (*Carcharhinus falciformis*), oceanic whitetip sharks display relatively low mitochondrial DNA genetic diversity (Camargo et al. 2016; Clarke et al. 2015; Ruck 2016). As noted previously, the species appears to display a high degree of philopatry to certain sites, with females giving birth on one side of a basin or the other, indicating little if any mixing with individuals of other regions (Howey-Jordan et al. 2013; Tolotti et al. 2015; Young et al. 2017). Thermal barriers (i.e., water temperatures less than 15° C) may prevent inter-ocean basin movements. Based in genetic analyses, there is significant population structuring between the Western Atlantic and Indo-Pacific Ocean populations (Ruck 2016).

Oceanic whitetip sharks are distributed throughout open ocean waters, the outer continental shelf, and around oceanic islands, primarily from 10° North to 10° South, but up to 30° North and 35° South (Young et al. 2017). They can be found at the ocean surface and down to at least 152 m deep, but most frequently stay between depths of 25.5 and 50 m (Carlson and Gulak 2012; Young et al. 2017). They display a preference for water temperatures above 20° Celsius, but can be found in waters between 15° and 28° Celsius, and can briefly tolerate waters as cold as 7.75° Celsius during dives to the mesopelagic zone (Howey-Jordan et al. 2013; Howey et al. 2016).

In the Western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. Essential Fish Habitat for the oceanic whitetip shark includes localized areas in the central Gulf of Mexico and Florida Keys, and depths greater than 200 m in the Atlantic (from southern New England to Florida, Puerto Rico, and the U.S. Virgin Islands). In the Northwest Atlantic, historically the species was widespread, abundant, and the most common pelagic shark warm waters (Backus et al. 1956). However, recent information suggests the species is now relatively rare in this region (Young et al. 2017).

Status and Trends

In addition to declines in oceanic whitetip catches throughout its range, there is also evidence of declining average size over time in some areas, and is a concern for the species' status given evidence that litter size is potentially correlated with maternal length. Such extensive declines in the species' global abundance and the ongoing threat of overutilization, the species' slow growth and relatively low productivity, makes them generally vulnerable to depletion and potentially slow to recover from overexploitation. Related to this, the low genetic diversity of oceanic whitetip sharks is also cause for concern and a viable risk over the foreseeable future for this species. Loss of genetic diversity can lead to reduced fitness and a limited ability to adapt to a rapidly changing environment. The biology of the oceanic whitetip shark indicates that it is likely to be a species with low resilience to fishing and minimal capacity for compensation (Rice and Harley 2012).

Oceanic whitetip sharks are afforded some protections from overharvesting within the action area (Miller and Klimovich 2017). The Micronesia Regional Shark Sanctuary Declaration, which includes the EEZs of Guam and CNMI, prohibits possession, sale, distribution and trade of sharks and rays and shark and ray parts (with some exemptions for research and subsistence fishing). Illegal harvest is likely still a problem given the large area and limited enforcement available.

Critical Habitat

No critical habitat has been designated for the oceanic whitetip shark.

Recovery Goals

NMFS has developed a recovery outline to serve as an interim guidance document to direct recovery efforts for the oceanic whitetip shark until a full recovery plan is developed and approved. The major actions recommended in the outline include:

- Maintain existing U.S. laws and regulations that protect sharks and prohibit retention of oceanic whitetip sharks in pelagic longline fisheries and some recreational fisheries.
- Improve understanding of bycatch and associated mortality rates (including at-vessel and post-release mortality) in key fisheries, including impacts of various factors such as gear type, hook type and depth, temperature, temporal and spatial fishing effort, interactions with fish aggregating devices, etc. for informing future fisheries management strategies to reduce fisheries interactions and associated mortality.
- Reduce primary threats (e.g., bycatch-related mortality in commercial fisheries) to prevent further declines in species' abundance and stabilize populations, including investigating best methods for safe release of oceanic whitetip sharks in longlines.
- Improve understanding of population distribution, abundance, trends, and structure through research, monitoring, and modeling.
- Identify and protect key habitat areas, including breeding and nursery grounds through research, monitoring, modeling, and management.

- Improve understanding of reproductive periodicity and seasonality to inform future management measures for minimizing impacts to the species during key life history functions.
- Review available information to determine if any countries continue to catch significant amounts of oceanic whitetip shark and/or are involved in the trade of oceanic whitetip fins to prioritize outreach and coordination for improving compliance with Regional Fisheries Management Organizations and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) requirements.
- Coordinate with relevant Regional Fisheries Management Organizations to improve, where needed, reporting and compliance related to current conservation measures for oceanic whitetip shark to address bycatch mortality.

6.2.13 *Acropora globiceps*

Acropora globiceps is a coral species distributed from the oceanic west Pacific to the central Pacific as far east as the Pitcairn Islands. In the U.S., *Acropora globiceps* occurs in American Samoa, the Northern Mariana Islands, and the U.S. minor outlying islands (Figure 42).

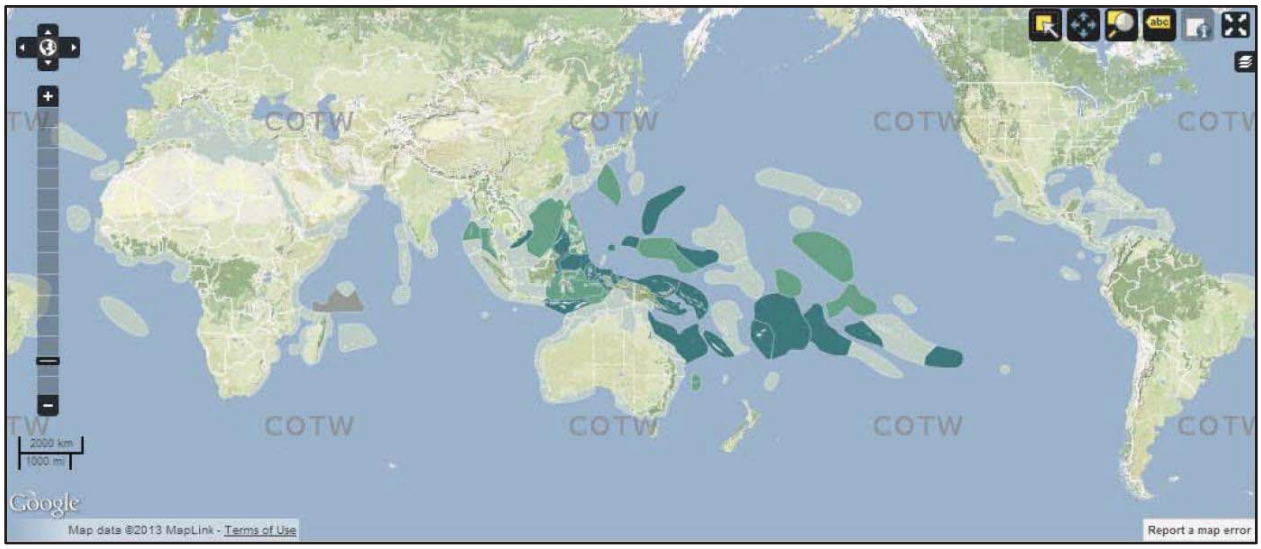


Figure 42. *Acropora globiceps* distribution. Off-white = no record, dark green = confirmed record, pale green = predicted record, tan = published record that needs further investigation (Veron 2014).

Colonies of *Acropora globiceps* are digitate and usually small. The size and appearance of branches depend on degree of exposure to wave action but are always short and closely compacted. Colonies exposed to strong wave action have pyramid-shaped branchlets. Corallites are irregular in size, those on colonies on reef slopes are tubular, and those on reef flat colonies are more immersed. Axial corallites are small and sometimes indistinguishable. Radial corallites are irregular in size and are sometimes arranged in rows down the sides of branches. Colonies

are uniform blue (which may photograph purple) or cream in color. *Acropora globiceps* was listed as threatened on September 10, 2014 (79 FR 53852).

We used information available in the 2011 status review (Brainard et al. 2011), the 2014 Veron (2014) report and the 2014 listing document (79 FR 53852) to summarize the life history, population dynamics and status of the species, as follows.

Life history

Acropora are sessile colonies that spawn their gametes into the water column; the larvae can survive in the planktonic stage from four to 209 days (Graham et al. 2008). This has allowed many *Acropora* species to have very wide geographic ranges, both longitudinally and latitudinally (Wallace 1999). However, sessile colonies must be within a few meters of each other to have reasonable success in fertilization (Coma and Lasker 1997). All species of the genus *Acropora* studied to date are simultaneous hermaphrodites (Baird et al. 2009), with a gametogenic cycle in which eggs develop over a period of about nine months and testes over about ten weeks (Szmant 1986; Wallace 1985). Fecundity in *Acropora* colonies is generally described as ranging from 3.6 to 15.8 eggs per polyp (Kenyon 2008; Wallace 1999). Mature eggs of species of *Acropora* are large when compared with those of other corals, ranging from 0.53 to 0.90 mm in mean diameter (Wallace 1999). For five *Acropora* species examined by Wallace (1985), the minimum reproductive size ranged from 4 to 7 cm, and the estimated ages ranged from three to five years.

Acropora spp. release gametes as egg-sperm bundles that float to the sea surface, each polyp releasing all its eggs and sperm in one bundle. Fertilization takes place after the bundles break open at the sea surface. Sperm concentrations of 106 ml-1 have been found to be optimal for fertilization in the laboratory, and concentrations of this order have been recorded in the field during mass spawning events. Self-fertilization, although possible, is infrequent. Gametes remain viable and achieve high fertilization rates for up to eight hours after spawning (Kenyon 1995). Embryogenesis takes place over several hours, and further development leads to a planula that is competent to settle in four to five days after fertilization.

Many *Acropora* have branching morphologies, making them potentially susceptible to fragmentation. Fragment survival can increase coral abundance in the short-term but does not contribute new genotypes (or evolutionary opportunities) to the population.

Delineation of Individuals of Acropora globiceps

Reef-building corals are clonal organisms. A single larva will develop into a discrete unit (the primary polyp) that then produces modular units (*i.e.*, genetically-identical copies of the primary polyp) of itself, which are connected seamlessly through tissue and skeleton. These modular units may be solitary (*e.g.*, fungiid corals) or colonial. Most reef-building coral species are colonial, including all species covered in the final rule (79 FR 53877). Colony growth is achieved mainly through the addition of more polyps, and colony growth is indeterminate. The

colony can continue to exist even if numerous polyps die, or if the colony is broken apart or otherwise damaged. The biology of such clonal, colonial species creates ambiguity with regard to delineation of the individual in reef-building corals, specifically: (1) polyps versus colonies; (2) sexually-produced versus asexually-produced colonies; and (3) difficulty determining colony boundaries (79 FR 53877).

The "polyp" could be considered the smallest unit of the individual for reef-building corals. Each polyp in a coral colony consists of a column of tissue with a mouth and tentacles on the upper side, growing in a cup-like skeletal structure (the corallite) made of calcium carbonate that the polyp produces through calcification. The polyps are the building blocks of the colony, and most colony growth occurs by increasing the number of polyps and supporting skeleton. Polyps carry out the biological functions of feeding, calcification, and reproduction. However, because the polyps within a colony are modular units, and connected to one another physiologically (*i.e.*, via nerve net and gastrovascular cavity, and are the same sex), single polyps within a colony were not considered by NMFS to be individuals for purposes of the final listing.

Colonies are founded by either sexually-produced larvae that settle and become the primary polyp of a colony, or asexually-produced fragments of pre-existing colonies that break off to form a new colony. Fragments from the same colony can fuse back together into the same colony if they are close enough to grow together. Fragmentation in branching species may lead to a large number of asexually-produced, genetically identical colonies, commonly resulting in a population made up of more asexually-produced colonies than sexually-produced colonies (Hughes 1984). Sexually-produced colonies are important to the population by increasing the genetic diversity of the population. Asexual reproduction, though it does not create new genetic individuals, is likely the more critical mode for some species, especially branching species, allowing them to grow, occupy space, and persist between relatively rare events of sexual reproduction. NMFS used the concept of the "physiological colony" as the entity considered to be an individual.

The physiological colony for reef-building colonial species is defined as any colony of the species, whether sexually or asexually produced (79 FR 53877). A physiological colony is generally autonomous from other colonies of the same species. However, colony morphology, partial colony mortality, and other colony growth characteristics (*e.g.*, formation of stands or thickets) can complicate the delineation of physiological colonies from one another in the field. In those cases, colony shape may not distinguish colonies from one another, and boundaries between separate encrusting colonies that have grown together may be difficult or impossible to make out visually. Partial mortality of colonies, especially larger colonies, can also mask the boundaries between colonies, because the algae-encrusted coral skeleton of a partially dead colony may appear to delineate two or more colonies. In addition, many reef-building coral species occur in stands or thickets that may be tens of meters or more in diameter (*e.g.*, some *Acropora* species), possibly consisting of multiple colonies or only one large colony, also

masking the boundaries between colonies. In each of these instances, the actual number of genetically-distinct individuals can only be determined through genetic analysis.

NMFS' final rule considered the "individual" for each of the proposed species including *Acropora globiceps*, to be the "physiological colony," as defined above. That is, polyps are not considered individuals, but sexually- and asexually-produced colonies are considered individuals because they are a type of physiological colony and are the unit that can be identified in the field.

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 *Acropora globiceps*.

Acropora globiceps is distributed from the oceanic west Pacific to the central Pacific as far east as the Pitcairn Islands. Veron (2014) reported that *Acropora globiceps* is confirmed in 22 of his 133 Indo-Pacific ecoregions, and strongly predicted to be found in an additional 16. Wallace (1999) reports its occurrence in seven of her 29 Indo-Pacific areas, many of which are significantly larger than Veron's ecoregions. The map presented in Wallace (1999) shows it from a smaller area than Veron (Veron, 2000; Veron, 2014). Based on the Wallace (1999) range, *Acropora globiceps* has a relatively small range, estimated at five million km^2 (Richards 2009). Within U.S. waters, this species is confirmed in American Samoa, Guam, CNMI, and the U.S. Pacific Remote Island Areas (http://www.fpir.noaa.gov/PRD/prd_coral.html).

Veron (2014) reports that *Acropora globiceps* occupied 3.2 percent of 2,984 dive sites sampled in 30 ecoregions of the Indo-Pacific, and had a mean abundance rating of 1.95 on a 1 to five rating scale at those sites in which it was found. Based on this semi-quantitative system, the species' abundance was characterized as ''uncommon.'' Overall abundance was described by Veron as ''sometimes common.'' Veron did not infer trends in abundance from these data. The absolute abundance of *Acropora globiceps* was estimated as at least tens of millions of colonies at the time of listing (79 FR 53852).

The overall decline in abundance ("Percent Population Reduction") was estimated at 35 percent, and the decline in abundance before the 1998 bleaching event ("Back-cast Percent Population Reduction") was estimated at 14 percent (Carpenter et al. 2008). However, live coral cover trends are highly variable both spatially and temporally, producing patterns on small scales that can be easily taken out of context, thus quantitative inferences to species-specific trends should be interpreted with caution. At the same time, an extensive body of literature documents broad declines in live coral cover and shifts to reef communities dominated by hardier coral species or algae over the past 50 to 100 years (Brainard et al. 2011). These changes have likely occurred, and are occurring, from a combination of global and local threats. Given that *A. globiceps* occurs in many areas affected by these broad changes, and that it has some susceptibility to both global and local threats, we conclude that it is likely to have declined in abundance over the past 50 to

100 years, but a precise quantification is not possible due to the limited species-specific information.

Acropora globiceps inhabits intertidal, upper reef slopes and reef flats (Veron 2000). Although it most commonly occurs at depths of 0 to 8 m (Veron 2000), it has been recorded as deep as 20 m in the Mariana Islands (Fenner and Burdick 2016). Within the Mariana Islands, *Acropora globiceps* is confirmed in both Guam and CNMI. *Acropora globiceps* is by far the most common ESA-listed coral species in the action area. On Guam, a recent review of available coral survey data from numerous sites around the island showed *Acropora globiceps* at dozens of locations. Several surveys have been conducted within Apra Harbor (e.g., (Smith et al. 2009); (Foster et al. 2007; Starmer 2008)) and in only three instances (Lybolt 2015; Schils et al. 2011), was *Acropora globiceps* observed. In April 2015, several colonies of ESA-listed *Acropora globiceps* were encountered during a 40-minute non-systematic survey at Spanish Steps in Outer Apra Harbor (Lybolt 2015). Another colony was recorded during a non-systematic survey of the nearshore area at Dadi Beach from the reef crest south of the beach in September 2016 (Navy 2019e).

Carilli et al. (2018) reported one confirmed colony and seven unconfirmed colonies that may have been *Acropora globiceps* within the survey areas surrounding FDM in a 2017 survey. The confirmed *A. globiceps* colony was not bleached, and only one of seven unconfirmed colonies was bleached. *Acropora globiceps* was not recorded in the 2001 or 2002 FDM surveys. In the 2003 and 2004 FDM coral surveys, *A. globiceps* was recorded on two individual dives as being "rare" (less than five colonies). These survey results suggests that *A. globiceps* has been consistently rare at FDM over the past few decades (Carilli et al. 2018). *A. globiceps* has also been recorded in Tinian and Pagan (Tech 2014).

Status and Trends

Acropora globiceps is highly susceptible to ocean warming, disease, ocean acidification, trophic effects of fishing, nutrients, and predation. These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms to address global threats that contribute to extinction risk for this species are inadequate. *Acropora* globiceps occurs primarily in depths of zero to eight meters which can be considered a shallow depth range compared to the overall depth of occurrence for reef building corals in general. Shallow reef areas are often subjected to highly variable environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. A limited depth range reduces the absolute area in which the species may occur throughout its geographic range and indicates that a large proportion of the population is likely to be exposed to threats that are worse in shallow habitats, such as simultaneously elevated irradiance and seawater temperatures, as well as localized impacts. The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Critical Habitat

Critical habitat has not yet been designated for this species.

Recovery Goals

A recovery plan has not yet been developed for this species.

7 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the ESA-listed species or its designated critical habitat in the action area, without the consequences to the ESA-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 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to ESA-listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02). The following information summarizes the principal natural and human-caused phenomena in the MITT Action Area believed to affect the survival and recovery of ESA-listed species (from Section 6.2 above) in the wild.

7.1 Climate Change

There is a large and growing body of literature on past, present, and anticipated future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA-listed resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov). This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur as the result of climate change. We address climate change as it has affected ESA-listed species and continues to affect species, and we look to the foreseeable future to consider effects that we anticipate will occur as a result of ongoing activities. While the consideration of future impacts may also be suited to our cumulative effects analysis below (Section 9), it is discussed here to provide a comprehensive analysis of the effects of climate change in one location within the document. While it is difficult to accurately predict the consequences of climate change 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 both within and outside of the Action Area.

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as

representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7°C under RCP2.6, 1.1 to 2.6°C under RCP 4.5, 1.4 to 3.1°C under RCP6.0, and 2.6 to 4.8°C under RCP8.5, with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2°C, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al. 2018).

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1.0°C from 1901 through 2016 (Hayhoe et al. 2018). The *IPCC Special Report on the Impacts of Global Warming (2018)* (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2°C above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3°C per decade. 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). Annual average temperatures have increased by 1.8°C across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (Allen et al. 2018). 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 (Allen et al. 2018).

Several of the most important threats contributing to the extinction risk of ESA-listed species, particularly those with a calcium carbonate skeleton such as corals and mollusks, as well as species for which these animals serve as prey or habitat, are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate habitats generally, and on ESA-listed corals and mollusks in particular, are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean [ocean acidification; (IPCC 2014)]. 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, and is predicted to increase considerably between now and 2100 (IPCC 2014).

Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Since the early 1980s, the annual minimum sea ice extent (observed in September each year) in the Arctic Ocean has decreased at a rate of 11 to 16 percent per decade (Jay et al. 2018). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, tropical storms, heat waves, and droughts (IPCC 2014).

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Evans and Bjørge 2013; IPCC 2014; Kintisch 2006; Learmonth et al. 2006; McMahon and Hays 2006; Robinson et al. 2005). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Isaac 2007), recent research has indicated a range of consequences already occurring. For example, in sea turtles, 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 sea turtle sex ratios toward higher numbers of females (NMFS and USFWS 2007a; NMFS and USFWS 2007d; NMFS and USFWS 2013a; NMFS and USFWS 2013b; NMFS and USFWS 2015). These impacts will be exacerbated by sea level rise. The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and

some predicted to experience losses. Notably, leatherback turtles were predicted to gain core habitat area, whereas loggerhead turtles and blue whales were predicted to experience losses in available core habitat. (McMahon and Hays 2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. Based upon expected shifts in water temperature, (MacLeod 2009) estimated 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction). Willis-Norton et al. (2015) acknowledged there will be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean.

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990). Pecl and Jackson (2008) predicted climate change 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 Eliott 2009).

Climate change can affect marine mammal species directly by causing them to shift their distribution to match physiological tolerance under changing environmental conditions (Doney et al. 2012; Silber et al. 2017), which may or may not result in net habitat loss. Climate change can also affect marine mammals indirectly via impacts on prey, changes in prey distributions and locations, and changes in water temperature (Giorli and Au 2017). Changes in prey can impact marine mammal foraging success, which in turn affects reproductive success and survival. Marine mammals are influenced by climate-related phenomena, such as typhoons and shifts in extreme weather patterns such as the 2015–2016 El Niño in the ocean off the U.S. West Coast. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Bradshaw et al. 2006; Marsh 1989; Rosel and Watts 2008; Zellar et al. 2017), or other oceanographic conditions. Climate change can influence marine mammal reproductive success by altering prey availability, as evidenced by the low success of Northern elephant seals (*Mirounga angustirostris*) during El Niño periods (McMahon and Burton 2005) as well as data suggesting that sperm whale females have lower rates of conception following periods of unusually warm sear surface temperature (Whitehead et al. 1997). However, gaps in information and the complexity of climatic interactions complicate the ability to predict the effects that

climate change and/or variability may have to these species from year to year in the action area (Kintisch 2006; Simmonds and Isaac 2007).

Sea turtles are particularly susceptible to climate change effects because their life history, physiology, and behavior are extremely sensitive to environmental temperatures (Fuentes et al. 2013). Climate change models predict sea level rise and increased intensity of storms and hurricanes in tropical sea turtle nesting areas (Patino-Martinez et al. 2008). These factors could significantly increase beach inundation and erosion, thus affecting water content of sea turtle nesting beaches and potentially inundating nests (Pike et al. 2015). Other impacts from climate change may include feminization of turtle populations from elevated nest temperatures (and skewing populations from more males to females unless nesting shifts to northward cooler beaches) (Reneker and Kamel 2016), decreased reproductive success (Clark and Gobler 2016; Hawkes et al. 2006; Laloë et al. 2016; Pike 2014), shifts in reproductive periodicity and latitudinal ranges (Birney et al. 2015; Pike 2014), disruption of hatchling dispersal and migration, and indirect effects to food availability (Witt et al. 2010).

7.1.1 Ocean Acidification and Coral Bleaching

Aspects of climate change that influence water quality include decreasing ocean pH (i.e., more acidic), increasing water temperatures, and increasing storm activity. Changes in pH outside the normal range can make it difficult for marine organisms with shells to maintain their shells (Fabry et al. 2008). Many of those creatures are at the base of the marine food chain, such as phytoplankton, so changes may reverberate through the ecosystem. Rising water temperatures combined with decreasing ocean pH can be detrimental to coastal ecosystems, particularly to corals and the communities that depend on them (Anthony et al. 2008). For example, in waters warmer than normal, coral colonies appear to turn white ("bleaching") because they expel symbiotic microbes (zooxanthellae) that give them some of their colors. These microbes are important for coral survival because they provide the coral with food and oxygen, while the coral provides shelter, nutrients, and carbon dioxide.

Coral bleaching can occur as a stress response to changes in light availability, nutrients, toxicants, or pathogens (NOAA 2017). Bleaching events have increased in frequency in recent decades, and coral bleaching on a global scale has been on the rise for decades (Donner and Carilli 2019).

Water pollution and natural disturbance (e.g., hurricanes) 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 (Corinaldesi et al. 2018; Downs et al. 2016).

Keener et al. (2015) documented a coral bleaching event off of Guam in 2013 through 2014. That event, combined with the strong associations between sea surface temperature increases and coral bleaching events throughout the Pacific (Griesser and Spillman 2016), suggests that it is highly likely sea surface temperature increases in the Mariana Islands are at least partially to blame for coral bleaching events. Raymundo et al. (2019) provide further discussion of the impacts of increased sea surface temperatures on local *Acropora* coral species around Guam. Elevated sea surface temperatures induced severe island-wide bleaching in 2013, 2014, 2016, and 2017. This coupled with an El Nino Southern Oscillation event triggered extreme low tides in 2014 that extended into 2015 and caused additional coral mortalities. These events have resulted in a loss of approximately 36 percent live *Acropora* spp. coral coverage (as of 2017) around Guam. Their data suggest that some coral species are at high risk of extirpation in these waters and that increasing bleaching events raise concerns that coral recovery may not keep pace with mortality. Furthermore, (Van Hooidonk et al. 2016) previously predicted that severe bleaching events around the Mariana Islands could begin as early as 2020, but events documented by Raymundo et al. (2019) suggest that Guam's shallow-water corals may not be able to adapt and keep pace with rapidly warming ocean temperatures.

7.2 Oceanic Temperature Regimes

Oceanographic conditions in the Pacific Ocean can be altered due to periodic shifts in atmospheric patterns caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events, and the Pacific decadal oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the action area (Beamish 1993; Benson and Trites 2002; Hare and Mantua 2001; Mantua et al. 1997; Mundy 2005; Mundy and Cooney 2005; Stabeno et al. 2004).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña/Southern Oscillation events. It is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific Ocean experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Childers et al. 2005; Hare et al. 1999). Sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. Cartwright et al. (2019) observed a 73 percent decrease in sightings of mother-calf pairs of humpback whales belonging to the Hawaii DPS between 2013 and 2018 during a positive shift in the Pacific decadal oscillation. This coincided with a buildup of warm water in the central, north, and eastern Pacific, which may have suppressed coastal upwelling and productivity, and therefore the availability of humpback whale prey, in these regions. However, more research needs to be done to determine what effects these phase shifts

have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Action Area. A shift to a colder or warmer decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

7.3 Coastal Development and Pollution

Coastal development intensifies use of coastal resources, resulting in potential impacts on water quality, marine habitat, and air quality. Development impacts coastal resources through point and nonpoint source pollution, increased sedimentation, concentrated recreational use, and intensive ship traffic using major port facilities. The Action Area coastline also includes coastal tourism development (e.g., hotels, resorts, restaurants, food industry, vacation homes) and the infrastructure supporting coastal development (e.g., retail businesses, marinas, fishing tackle stores, dive shops, fishing piers, recreational boating harbors, beaches, recreational fishing facilities). Coastal development is regulated by states and territories through the Coastal Zone Management Act and associated state and local programs.

Habitat degradation issues associated with development, such as poor water quality, invasive species, and disease, can alter ecosystems, limiting food availability and altering survival rates. For example, on Saipan, golf course, hotel and tourism-related development has severely impacted most of the historical sea turtle nesting areas on the western portion of the island and residential development threatens the eastern portion of the island. On Rota, turtle nesting beaches appear limited to undeveloped private land due to heavy recreational use and shoreside tourist developments. On Tinian, the majority of the nesting beaches are on military-leased land where no construction is presently expected.

Pollution of the marine environment is a pervasive problem throughout Guam and the inhabited Mariana Islands. Portions of the nearshore marine environment around Guam were severely degraded by impacts from intense combat during World War II (WWII); sunken ships still rest on the sea floor at several locations throughout Apra Harbor on Guam, as does metallic wreckage and other debris. Since WWII, the health of Guam’s marine environment has been affected by the recreational, industrial and commercial operations associated with an increasing population. More recently, sedimentation (from illegal wildfires, improper development, and upland erosion), stormwater runoff and associated pollutants such as fertilizers and oil (from inadequate protections during coastal development and insufficient stormwater management practices and infrastructure) have been identified as the most serious threats to the health of Guam’s nearshore marine environment. Increases in soil erosion can lead to sediment loading in coastal waters which directly impact reef building corals and indirectly impact sea turtles by altering habitat including coral reefs and sea grass beds.

The most common direct effect of sedimentation is deposition of sediment on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments or corals can actively displace sediment by ciliary action or mucous production, both of which require energetic expenditures (Bak and Elgershuizen 1976;

Dallmeyer et al. 1982; Lasker 1980; Stafford-Smith 1993; Stafford-Smith and Ormond 1992). Corals that are unsuccessful in removing sediment will be smothered and die (Golbuu et al. 2003; Riegl and Branch 1995; Rogers 1983). Sediment can also induce sublethal effects, such as reductions in tissue thickness (Flynn et al. 2006) and excess mucus production (Marszalek 1981). In addition, suspended sediment can reduce the amount of light in the water column, resulting in less energy available for coral photosynthesis and growth (Anthony and Hoegh Guldberg 2003; Bak 1978; Rogers 1979). While some corals may be more tolerant of short-term elevated levels of sedimentation, sediment stress and turbidity can induce bleaching (Philipp and Fabricius 2003; Rogers 1979). Finally, sediment impedes fertilization of spawned gametes (Gilmour 2002; Humphrey et al. 2008) and reduces larval settlement, as well as the survival of recruits and juveniles (Birrell et al. 2005; Fabricius et al. 2003).

The effects of chemical pollution on marine mammals are just starting to be understood (Aguilar Soto et al. 2008). Recently, the 5.5-year expedition of the *Odyssey* collected 955 biopsy samples from sperm whales around the world to provide a consistent baseline database of ocean contamination and to measure future effects (Ocean Alliance 2010). Chemical pollutants found in pesticides and other substances flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber, internal organs, or are transferred to the young from mother's milk (Fair et al. 2010). Important factors that determine the levels of pesticides, heavy metals, and industrial pollutants that accumulate in marine mammals are gender (i.e., adult males have no way to transfer pesticides whereas females may pass pollutants to their calves through milk), habitat, and diet. Living closer to the source of pollutants and feeding on higher-level organisms increase the potential to accumulate toxins (Moon et al. 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors but also compromises the function of their reproductive systems (Fair et al. 2010).

In addition to the effects of sediment-laden and polluted runoff, Guam's nearshore waters have been impacted by years of poorly treated wastewater effluent discharges around the island. In 1986, the U.S. Environmental Protection Agency issued permits under the National Pollutant Discharge Elimination System (NPDES) that allowed Guam Waterworks Authority to discharge wastewater effluent into the nearshore marine environment following primary treatment of wastewater. Primary treatment follows coarse screening and grit settlement, and removes only about 60 percent of the suspended solids in the wastewater by allowing the water to rest in settlement tanks that are used to remove material that floats or settles out (Mancl 1996). Following that, chlorination is normally employed to reduce pathogens. However, the NPDES permits expired in 1991 and were not reissued due to Guam Waterworks Authority's inability to meet the required standards (Guam 2003).

The Department of the Navy (DON) has requested a modification of the NPDES permit for discharges from the municipal separate storm sewer system (MS4) operated by DON on the Island of Guam (NPDES permit No. GUS040000). The discharges regulated by the permit

consist primarily of stormwater runoff but could also include certain specified non-stormwater discharges as well. The final MS4 permit for DON was issued on December 20, 2018 and became effective on February 1, 2019. The permit requires development and implementation of a stormwater management program (SWMP) including various best management practices (BMPs) designed to control discharges of pollutants from the MS4 in accordance with a schedule that is set forth in the permit. The requested permit modification would extend the deadlines for the SWMP and BMPs by one year (EPA 2019).

The lack of adequate wastewater treatment on Guam has contributed to nutrient inputs to nearshore waters. A 2010 assessment by Guam Environmental Protection Agency determined that while most of the 24 assessed bays met water quality guidelines for recreational activities and harvesting, 11 of the bays were impaired. Over 700 swimming advisories due to bacterial counts in marine waters were issued in 2009, likely stemming from faulty septic tanks and non-compliance by treatment facilities with NPDES regulations for various parameters.

The overall health of Guam's coral reefs has declined over time; while it is difficult to assign the causes of this decline to local versus global causes, increased sedimentation and pollutant runoff are known stressors to reef-building corals. The average live coral cover in Guam's nearshore waters was approximately 50 percent in the 1960s, but dwindled to less than 25 percent by the 1990s, with only a few areas having over 50 percent live cover.

7.3.1 Light Pollution

Sea turtle hatchlings are strongly attracted to light (Witherington and Bjorndal 1991), and use light wavelengths and shape patterns to find the ocean after emerging from the nest (Lohmann et al. 1997; Witherington 1992). The east end of Apra Harbor is highly developed and brightly illuminated at night. The existing lights from this commercial port may be clearly visible to nesting turtles and hatchlings and could potentially impact green turtle reproductive success at the Spanish Steps location.

7.4 Marine Debris

Marine debris can be introduced into the marine environment by its improper disposal, accidental loss, or natural disasters (Watters et al. 2010), and can include plastics, glass, derelict fishing gear, derelict vessels, or military expendable materials. Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (Academies 2008) and continues to accumulate in the ocean and along shorelines. Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it. Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, as well as mortality through drowning for air breathing marine species including sea turtles and cetaceans. Marine debris ingestion can lead to intestinal blockage which can impact feeding ability and lead to death. Information on marine debris in the action area is largely lacking; therefore it is

difficult to draw conclusions as the extent of the problem and its impacts on populations of listed species.

Recently, Richardson et al. (2017) reported that from 2003-2015 fisheries observer data for the western and central Pacific Ocean recorded over 10,000 incidents of pollution related to purse-seine and longline fisheries vessels. The largest percentage (37 percent) of the purse-seine incidents were related to plastics waste, 16 percent as oil spillage or leakage, 15 percent as metals, 13 percent as abandoned, dumped, or lost fishing gear, nine percent as waste oil, eight percent as garbage, and two percent as chemicals. The incidents in the Guam and Northern Mariana Islands area (n=25) constituted less than one percent of the overall incidents reported. However, data reported are tentative and may be more extensive than thought.

Plastic debris is the most dominant type of marine debris in the Western Pacific, which includes the Mariana Islands. A plastic bag was found as deep as 10,898 m in the Mariana Trench, showing that marine debris also has implications for deep-sea ecosystems (Jamieson et al. 2019). Another study found the presence of ingested microplastics in amphipod populations living in six deep ocean trenches, including the Mariana Trench (Chiba et al. 2018). This discovery is the deepest record of microplastic ingestion.

Recent research (Germanov et al. 2019)evaluated the contribution of microplastics to the diet of filter-feeding megafauna (manta rays and whale sharks) at three coastal locations in Indonesia. Their data show that plastic abundance ranged from 0.04-0.09 pieces per meter squared (based on trawls) and 210-40,844 pieces per km^2 (visual surveys)(Germanov et al. 2019). (Germanov et al. 2019) calculated the theoretical plastic ingestion rates using estimated filtration volumes of manta rays and whale sharks and the mean plastic abundance in their feeding grounds. Their estimates ranged from approximately 25-63 pieces per hour for manta rays, and approximately 137 pieces per hour for whale sharks.

Sperm whales are also adversely affected by the ingestion of marine debris. A dead sperm whale just recently (12/2/2019) stranded on the Isle of Harris in Scotland’s Outer Hebrides. During the necropsy by the Scottish Marine Animal Stranding Scheme approximately 220 pounds of plastics was found in it’s stomach, including a massive ball of fishing nets and line (Sullivan 2019).

Sea turtles can mistake plastic bags for jellyfish, which are eaten by many turtle species in early life phases, and exclusively by leatherback turtles throughout their lives. One study found plastic in 37 percent of dead leatherbacks and determined that nine percent of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). In studying ingestion in 115 green and hawksbill sea turtles stranded in Queensland, Schuyler et al. (2012) found that the probability of debris ingestion was inversely correlated with size (curved carapace length), and when broken down into size classes, smaller pelagic turtles were significantly more likely to ingest debris than larger benthic feeding turtles. Parker et al. (2005) conducted a diet analysis of 52 loggerhead sea turtles collected as bycatch from 1990 to 1992 in the high seas drift gillnet fishery in the central north Pacific. The authors found that 34.6 percent of the individuals sampled had anthropogenic

debris in their stomachs (e.g., plastic, Styrofoam, paper, rubber, etc.). Similarly, a study of green sea turtles found that 61 percent of those observed stranded had ingested some form of marine debris, including rope or string, which may have originated from fishing gear (Bugoni et al. 2001). In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impaction was the cause of both deaths. Jacobsen et al. (2010) speculated that the debris likely accumulated over many years, possibly in the North Pacific gyre that would carry derelict Asian fishing gear into eastern Pacific waters.

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al. 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyls (or PCBs) and Dichlorodiphenyltrichloroethane (or DDT). Fish, marine mammals and sea turtles can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. In the North Pacific Subtropical Gyre it is estimated that the fishes in this area are ingesting 12,000 to 24,000 U.S. tons (10,886,216 to 21,772,433 kg) of plastic debris a year (Davison and Asch 2011).

Other marine debris, including derelict fishing gear and cargo nets, can entangle and drown turtles of all life stages. In December 2013, a distressed juvenile hawksbill turtle was found entangled in marine debris in Garapan Lagoon, Saipan; a nylon rope tied in a loop had caught around the turtle’s carapace and the turtle’s body had apparently distorted around the restricting rope as it grew (Figure 43). The rope was removed and the turtle was released alive.

Between October 2004 and September 2008, the American Samoa Department of Marine and Wildlife Resources necropsied four green turtles that stranded on Tutuila. Two of these turtles had plastic and aluminum in their guts (Tagarino et al. 2008). However, because only a small percent of dead or dying sea turtles strand, little information is available to adequately quantify the impacts on sea turtles that may result from marine debris in the action area. Accumulated marine debris on sea turtle nesting beaches can also impede nesting success by altering nest excavation and through potential entrapment of hatchlings under debris that is inadvertently buried over them when the nesting female covers the clutch. The green sea turtle nesting beaches in the Spanish Steps area on Guam are heavily impacted by accumulated marine debris. We assume that sea turtle nesting in other portions of the Action Area may be similarly affected by marine debris, particularly in proximity to population centers (e.g., Saipan, Tinian and Apra Harbor, Guam).

Figure 43: Juvenile hawksbill turtle entangled in marine debris recovered in Garapan Lagoon, Saipan, December 2013. Image: CNMI Department of Lands & Natural Resources.

7.5 Fisheries

Fisheries constitute an important and widespread use of the ocean resources throughout the Action Area. Fisheries can adversely affect fish populations, other species, and habitats. Direct effects of fisheries interactions with ESA-listed species include entanglement and entrapment which can lead to fitness consequences or mortality as a result of injury or drowning. Indirect effects include reduced prey availability and destruction of habitat. Use of mobile fishing gear, such as bottom trawls, disturbs the seafloor and reduces structural complexity. Indirect impacts of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), removal of predators, ghost fishing (i.e., lost fishing gear continuing to ensnare fish and other marine animals), and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle or be ingested by marine mammals.

Fisheries can have a profound influence on fish populations. In a study of retrospective data, Jackson et al. (2001) analyzed paleoecological records of marine sediments from 125,000 years ago to present, archaeological records from 10,000 years before the present, historical documents, and ecological records from scientific literature sources over the past century. Examining this longer-term data and information, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change.

Fisheries in the action area range from relatively small-scale, nearshore fisheries to large-scale longline and purse seine fisheries operating further offshore. Nearshore fisheries in the action area are based out of Guam or CNMI and operate from shore or out of small boats with little distinction among commercial, subsistence, or recreation trips (Council 2011). Nearshore fishing methods include casting (rod & reel fishing), throw-netting, and spearfishing. Offshore fisheries in the action area are primarily commercial fisheries, and include high seas fishing activity from

foreign vessels. Offshore fishing typically involves small boats (12–48 ft in length) that engage in one to two day trolling and bottom fishing trips to nearby banks, isles and pelagic areas. There are a few larger boats that have been used in recent years for bottom fishing around the islands north of Saipan in addition to trolling. Data from the NOAA Pacific Islands Fishery Science Center indicates that the top fisheries in Guam in 2012, by weight, included skipjack tuna, mahi mahi, wahoo, and marlins, as well as reef fish such as parrotfish and unicornfish. Reef fishes make up a significant portion of the total commercial catch and are an important component of the local diet. While the vast majority of the domestic catch is consumed locally, there have been some intermittent exports to Guam, Hawaii, and Japan. Domestic fisheries based in Guam and the CNMI likely represent only a small percentage of the total fishing effort in the action area. International fleets, mainly from Asian nations, operate offshore and target pelagic species such as tunas, sharks and mahi mahi.

7.5.1 Bycatch

The term “bycatch” refers to any fisheries capture that is incidental to the intended or targeted species and can encompass all unwanted, unmanaged, or discarded animals captured. Fisheries bycatch has been identified as a primary driver of population declines in several groups of marine species, including sharks, mammals, marine birds, and sea turtles (Wallace et al. 2010). Bycatch is likely the most impactful problem presently facing cetaceans worldwide and may account for the deaths of more marine mammals than any other cause (Geijer and Read 2013; Hamer et al. 2010; Northridge 2008; Read 2008). Cetaceans are prone to bycatch in longline, trawl and purse seine fisheries, and large whales are prone to entanglement in trap or pot fisheries. Entanglement may also make whales more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed. We know very little about incidental fisheries interactions with cetaceans in the nearshore waters surrounding Guam and the CNMI. At the time this opinion was written, the NMFS Pacific Islands Regional Office have reported a few observations of injuries likely caused by fishing gear: a spotted dolphin was observed near Guam with an indentation around the body, indicative of being wrapped in line or a net; two short-finned pilot whales were seen with severe cuts judged to be caused by fishing line; and there are photographs of a Bryde’s whale with rope around its head. The pilot whales and Bryde’s whale were seen northwest of the archipelago in pelagic waters (email correspondence with Erin Oleson, NMFS PIFSC PRD, October 2019). There are no reports of ESA-listed cetaceans and fisheries interactions in the action area at this time.

Fishing fleets based out of Guam and CNMI are small in scale and there are very few longline vessels or purse seine vessels that operate out of regional ports; thus fisheries interactions with cetaceans would be less likely among these vessels than among the larger scale fishing fleets that operate offshore within the action area. While we suspect that other interactions with cetaceans and sea turtles likely occur among the offshore fisheries in the action area, data on these offshore fleets is scarce.

Wallace et al. (2010) estimated that worldwide, 447,000 turtles are killed each year from bycatch in commercial fisheries. It is likely that the majority of individual sea turtles and marine mammals that are killed by commercial fishing gear are never detected, making it very difficult to accurately determine the number and frequency of mortalities. In a study of stranded green turtles in Hawaii (those that are found on shore either injured, sick, or dead), the second and third most common known causes of stranding were fishing related. Hook-and-line fishing gear-induced trauma accounted for seven percent, and gillnet fishing gear-induced trauma was responsible for five percent (Chaloupka et al. 2008). However, most turtles that drown in fishing gear are likely never documented, making it very difficult to estimate the total number of turtles killed annually by nearshore fishing interactions, even in Hawaii where turtles are much better monitored and studied than in the Marianas.

Fisheries in the action area are likely to result in the incidental capture and mortality of green, loggerhead, leatherback and hawksbill sea turtles, though data on sea turtle bycatch in the region are lacking. As greens and hawksbills nest on Guam and the CNMI, they are more likely to be encountered in nearshore waters, and therefore more likely to be affected by nearshore fisheries based on Guam and the CNMI. Gill nets generally represent the most problematic fishery for sea turtles because the nets are often left untended, increasing the likelihood of drowning. Guam law prohibits drift gill nets and requires that staked gill nets be moved every six hours; these regulations would be expected to reduce the probability of mortality for any turtles incidentally captured. No such laws regarding gill nets exist in the CNMI that we are aware of. Sea turtles can also be hooked or entangled in hook-and-line fisheries, though the chance of survival is considered higher than if caught in a gill net. Leatherback sea turtles are known to have been occasionally captured offshore by Guam-based fishermen (Karen Frutchey, NMFS PIRO PRD, personal communication to Jordan Carduner, NMFS OPR, September 2014).

Bycatch of scalloped hammerhead sharks, oceanic whitetip sharks, and giant manta rays likely occurs in the action area, though we are not aware of any data that are specific to the Action Area. In Guam, anecdotal reports suggest that Apra Harbor may serve as a pupping ground for scalloped hammerhead sharks, based on the observed presence of young scalloped hammerhead sharks in Sasa Bay and Inner Apra Harbor (Miller et al. 2014a; NMFS 2015a). Therefore, incidental fisheries interactions with scalloped hammerheads within or just outside of Apra Harbor is a possibility; however we were not able to locate data on such bycatch other than anecdotal reports. As discussed above for sea turtles, Guam’s gill net regulations may also serve to reduce the probability of mortality for any sharks incidentally captured in gill nets.

7.5.2 Directed Fisheries

The directed hunting of sea turtles in foraging areas and on nesting beaches as well as the harvesting of eggs from nesting beaches represent ongoing threats to sea turtles in the action area. Directed take through harvest of turtles and their nests continues on Guam and the other inhabited islands of the Mariana archipelago. Turtles were traditionally taken by residents of

Guam for celebrations, and reports indicate that illegal harvesting still occurs. Poaching also occurs by immigrants, fishing crews, and tourists, especially those from areas where they are accustomed to eating turtles legally.

Between October 2013 and October 2014, the CNMI Department of Lands & Natural Resources reported two cases of attempted poaching of juvenile green sea turtles and one case of recovered juvenile green turtle remains that appeared consistent with poaching activity on Saipan, as well as the confiscation of five juvenile green turtle carapaces at Saipan International Airport. During the 2009 nesting season on Saipan, three out of what is thought to be a total of five nesting turtles were poached as were three nests. On Guam, DAWR has responded to 17 poachings of green sea turtles and one hawksbill since 1975. It is likely that the documented cases of poaching of adult sea turtles and sea turtle eggs represent just a fraction of the actual poaching cases that occur in the action area. Despite the evidence of continued poaching of adult sea turtles and sea turtle eggs, the available data on these activities is not adequate to allow for an accurate estimate of the impacts to listed sea turtle species in the action area.

Figure 44: Evidence of attempted poaching in the CNMI: A live juvenile green turtle found flipper-bound by a rubber strap, Saipan, 13 February 2014. Image courtesy of CNMI Department of Lands & Natural Resources.

Sharks and rays are afforded some protections from direct harvest within the action area (Miller and Klimovich 2017). The Micronesia Regional Shark Sanctuary Declaration, which includes the EEZs of Guam and CNMI, prohibits possession, sale, distribution and trade of sharks and rays and shark and ray parts (with some exemptions for research and subsistence fishing). Illegal harvest is likely still a problem given the large area and limited enforcement available. Assessing harvest levels of scalloped hammerheads in the action area is difficult because many catch records do not differentiate among hammerhead species, or shark species in general (Miller et al. 2014a). For the nearshore fishery, the Western Pacific Fisheries Information Network houses reported catch data from the fishery agencies of Guam (Division of Aquatic and Wildlife Resources; Bureau of Statistics and Plans) and CNMI (Division of Wildlife). However, reported shark catches for Guam and CNMI are aggregated into “Pelagic fishes” or “Sharks” categories

for reporting purposes, making it difficult to differentiate scalloped hammerhead catch from these data. Similarly for the offshore environment, until 2011, the Western and Central Pacific Fisheries Commission (WCPFC) did not require the offshore fishery in the Convention Area (inclusive of the Action Area) to report species specific information for many shark species, including hammerheads.

Observer data appears to be the most useful representation of species-specific catch rates in the offshore fishery of the Action Area (though it should be noted that these data are from observed fishing trips throughout the western and central Pacific Ocean and are not specific to the Action Area). Observer data from 1994 to 2009 indicates that hammerhead shark catch accounted for 0.2 percent of the total observed catch, by weight for longline fisheries (Programme 2010). Observer data from the purse seine fishery during the same time period indicated even lower shark catch rates: excluding catches of silky, whale, and oceanic whitetip sharks which were reported separately, catches of “Other sharks and rays” (inclusive of scalloped hammerhead sharks) represented only 0.01 percent of the total catch by weight of observed purse seine catches.

Scalloped hammerheads, oceanic whitetips and giant manta rays are targeted for their fins because they fetch a high commercial value in the Asian shark fin trade. Sharks and rays are likely under-reported in catch records as many records do not account for discards, or finned individuals (Miller et al. 2014a). Observer data from the longline fisheries of the Western and Central Pacific Ocean indicates that of the 104 scalloped hammerheads observed discarded from 1994-2009 (on over 3,000 observed trips), 72 percent of those discarded were finned. It should be noted that only a very small percentage of fishing vessels in the offshore portions of the Action Area have observer coverage, and many of the vessels that are most likely to be engaged in shark finning activities are also least likely to carry observers onboard. Many countries and fisheries management entities have aimed to restrict shark finning, though the practice continues in many areas. Since 2008, the Western and Central Pacific Fisheries Commission has attempted to discourage shark finning by requiring that fishing vessels retain all parts of the shark excepting head, guts, and skins, to the point of first landing. Further, onboard fins cannot weigh more than five percent of the weight of sharks onboard, up to the first point of landing. Despite these restrictions, illegal fishing activity is well documented, particularly on the high seas where enforcement is lacking.

7.6 Whaling

Large whale populations in the action area have historically been impacted by commercial whaling. During the height of global whaling, Guam was an important stopover for whaling ships in the Pacific Ocean. We are not aware of any directed hunting of whales that presently occurs in the action area. Prior to current prohibitions on whaling, most large whale species had been significantly depleted to the point where they faced extinction risks high enough to be listed under the ESA. Since the end of large-scale commercial whaling, the primary threat to these

species has been eliminated. However, not all whale species have recovered from those historic declines, which for many populations likely continues to influence their recovery potential Table 54 lists the reported catches of all whale species considered in this opinion and the year in which the IWC issued a moratorium on harvest of that species. These whaling numbers represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialist Republics catch records indicate extensive illegal whaling

Table 54. Reported Catch of Endangered Whales Considered in this Opinion, in the North Pacific Ocean.

Species	Estimated total catch	Data years	Source	IWC moratorium
Blue whale	9,500 whales	1910 - 1965	(Ohsumi and Wada 1972)	1966
Fin whale	46,000 whales	1919 - 1945	(C. Allison, IWC, pers. comm.; cited in : (Carretta et al. 2014)	1976
Humpback whale	15,000 whales	1919 - 1987	(Tonnessen and Johnsen 1982); C. Allison, IWC unpubl. Data; cited in: (Carretta et al. 2014)	1966
Sei whale	61,500 whales	1947 - 1987	(C Allison, IWC, pers. comm.(Allison 2007)	1976
Sperm whale	258,000 whales	1947 - 1987	(C. Allison, IWC, pers. comm.; cited in: (Carretta et al. 2014)	1988

activity between 1948 and 1979, with a harvest totalling 157,680 sperm whales in the North Pacific Ocean (Ivashchenko et al. 2014). Of these, only 132,505 were reported by the USSR to the Bureau of International Whaling Statistics. Additionally, despite the moratorium on large-scale commercial whaling, catch of some of these species still occurs in the Pacific Ocean whether it be under objection of the IWC, for aboriginal subsistence purposes, or under IWC special permit. Although these fisheries operate outside of the Action Area, some of the whales killed in these fisheries are likely part of the same populations of whales occurring within the action area for this consultation. Table 55 shows catches taken in the Pacific Ocean by commercial, aboriginal, and scientific permit whaling since 1985.

Table 55. Catches taken in the Pacific Ocean by commercial, aboriginal, and scientific permit whaling since 1985[1].

Year	Sperm whale	Sei whale
1985	0	0
1986	200	0
1987	188	0
1988 - 1999	0 all years	0 all years
2000	5	0
2001	8	1
2002	5	40
2003	10	50
2004	3	100
2005	5	100
2006	6	101
2007	3	100
2008	2	100
2009	1	101
2010	3	100
2011	1	96
2012	3	100
2013	1	100
2014	0	90
2015	0	90
2016	0	90
2017	0	134
Totals	444	1,493

[1] Note that the large majority of these catches were taken in the Northwest Pacific Ocean by either Japan or Russia (USSR prior to 1992). Data compiled from the IWC website (iwc.int/home; accessed on October 2, 2019).

7.7 Ongoing U.S. Military Training and Testing Activities in the action area

The majority of the training and testing activities the Navy conducts in the MITT Action Area and proposes to continue to conduct are similar, if not identical, to activities that have been

occurring in the same locations for decades. This following information summarizes the U.S. Pacific Fleet marine species monitoring that has occurred under the MMPA LOA for at-sea training in the MIRC. These data were provided by the Navy in the Comprehensive Exercise and Marine Species Monitoring Report for The U.S. Navy's Mariana Islands Range Complex. Department of the Navy, Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. September 2019.

Two individual MTEs took place in the MIRC from August 3, 2015 to August 2, 2019. There were 3 reported sightings of whales during these two MTEs and are summarized in Table 56 and Table 57 below.

Table 56. Summary of major training exercises from 2015 to 2019.

Exercise Type	03 Aug 2015 - 02 Aug 2016	03 Aug 2016 - 02 Aug 2017	03 Aug 2017 - 02 Aug 2018	03 Aug 2018 - 02 Aug 2019	Reporting Period Total
Joint Multi-Strike Group Exercise	0	1	0	1	2
Total	0	1	0	1	2

Table 57. Summary of animal sightings during major training exercises.

Marine Species	03 Aug 2015 - 02 Aug 2016	03 Aug 2016 - 02 Aug 2017	03 Aug 2017 - 02 Aug 2018	03 Aug 2018 - 02 Aug 2019	Reporting Period Total
	Estimated Number of Sightings of Animals While Sonar Active				
Dolphin	0	0	0	0	0
Whale	0	0	0	0	0
Pinniped	0	0	0	0	0
Turtle	0	0	0	0	0
Generic	0	0	0	0	0
Subtotal while Active	**0**	**0**	**0**	**0**	**0**
	Number of Sightings of Animals While Sonar Passive				
Dolphin	0	0	0	0	0
Whale	0	0	3	0	3
Pinniped	0	0	0	0	0
Turtle	0	0	0	0	0
Generic	0	0	0	0	0
Subtotal while	0	0	0	0	0
Total	**0**	**0**	**3**	**0**	**3**

There were no mitigation events where active sonar was powered down or shut down due to the sighting of marine mammals or sea turtles during MTEs from August 3, 2015 to August 2, 2019. The Navy's unclassified annual exercise reports from 2015 through August 2019 contain tables listing all marine mammals sighted during that reporting year and the range of the sighting.

7.8 Other U.S. Military Activities in the Action Area

The following sections describe other past and ongoing military activities in the MITT Action Area.

7.8.1 Surveillance Towed Array Sensor System Low Frequency Active Sonar

The Navy operates up to four Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar vessels. Based on current Navy national security and operational requirements, training and testing with these sonar systems could occur western and central North Pacific (including the Action Area) and eastern Indian oceans. During training and testing with SURTASS LFA sonar, the Navy employs a three-part mitigation and monitoring protocol to avoid or minimize the risk of injury to protected species: 1) visual monitoring for protected species during daylight hours, 2) passive (low-frequency) SURTASS to listen for sounds generated by marine mammals as an indicator of their presence, and 3) high frequency active sonar to detect potentially affected protected species. If protected species are detected within the mitigation zone while LFA sonar is active, sonar is suspended or delayed.

Additional SURTASS LFA sonar mitigation applies to coastal waters within 12 NM (22 km) of emergent land (which includes Saipan). This coastal standoff zone encompasses the Chalan-Kanoa Reef and Marpi Reef geographic mitigation areas established for the MITT proposed action. The SURTASS coastal waters mitigation states that no LFA sonar shall be operated during training and testing such that the SURTASS LFA sonar sound field exceeds 180 dB (re: 1μPa [rms]) within these areas.

The Navy also established a seasonal (February to April) Marianas Humpback Whale Overseas Biologically Important area which encompasses the 12 NM coastal water mitigation zone (including the Chalan-Kanoa Reef and Marpi Reef) as well as additional offshore waters. The Marianas Humpback Whale Overseas Biologically Important mitigation states that no LFA sonar shall be operated during training and testing such that the SURTASS LFA sonar sound field exceeds 180 dB (re: 1μPa [rms]) within 0.54 NM of the boundary of any OBIA during biologically important seasons and that no more than 25 percent of the authorized amount of SURTASS LFA sonar for training and testing activities within 10 NM of any single OBIA during any year unless required for national security.

As a requirement of the ESA and MMPA authorizations for this activity, the Navy submits annual reports to NMFS detailing the number of training and testing activities conducted, number of protected species observed or detected (either passive or active sonar detection), and the number of times LFA sonar was suspended or delayed due to the presence of a protected species. Both the historical and the recent results of the mitigation monitoring and effectiveness support the U.S. Navy's and NMFS' assertions that the U.S. Navy's three-part mitigation and

monitoring protocols provide an effective means of avoiding risk of injury to protected marine species. There have not been any reports of take from this activity in the action area.

7.8.2 Dredging, Filling, and Explosive Clearing

Apra Harbor is a natural deep-water harbor, which has been heavily modified, particularly since World War II (Figure 45). Much of the harbor's current topography and bathymetry is manmade; the result of work begun by the U.S. Government in 1943. Extensive dredging and fill projects resulted in the creation of Inner Apra Harbor and its channel as well as the creation of Dry Dock Peninsula, Polaris Point, and the manmade northeastern and southeastern shorelines and the Glass Breakwater, which extends from Cabras Island, out and across Luminau Reef to provide increased protection for the harbor. Other impacts include the knolls (hard bottom sites that protrude at least 25 ft (7.6 m) above the harbor bottom) that were explosively cleared during WWII because they were considered navigational hazards. Some of the shallower knolls have been used as anchorage sites since WWII, and some are still used by military and commercial vessels. The Guam and CNMI military relocation involves additional dredging in Inner Apra Harbor (Office 2010). Maintenance dredging within Apra Harbor is performed as necessary to maintain navigable depths (DON 2019).

Upcoming projects to dredge the channel, large sections of Inner Apra Harbor, and repair or improve Lima, Mike, November, Oscar, Papa, Quebec, and Romeo Wharves will likely affect coral and other benthic resources within Inner Apra Harbor. Wharf faces and support structures that have been present for at least several years and are not scoured by vessel activities typically harbor thick communities of fouling organisms. The species of fouling organisms include corals, none of which are ESA-listed species.

Figure 45. Apra Harbor, July 1945. The yellow line indicates the approximate shoreline prior to the dredging and fill projects of the 1940s.

7.9 Vessel Strike

Vessel strike is a significant concern for the recovery of ESA-listed whales and sea turtles. Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). Therefore, it is likely that the number of documented cetacean mortalities related to ship strikes is much lower than the actual number of mortalities associated with ship strikes.

The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately ten knots, with faster vessels, especially of large vessels (80 m or greater), being more likely to cause serious injury or death (Conn and Silber 2013; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. Injuries to whales killed by vessel strikes include huge slashes, cuts, broken vertebrae, decapitation, and animals cut in half (Carillo and Ritter 2010).

Compared to vessel strikes of large whales, it is often more difficult to detect when a vessel strikes a turtle. This is largely due to the relatively small size of a sea turtle compared to the commercial and military vessels used in the action area. Ship strikes are a poorly-studied threat to sea turtles, but have the potential to be highly significant (Work et al. 2010). All sea turtles must surface to breathe and several species are known to bask at the surface for long periods,

including loggerhead sea turtles, which increase the risk of ship strike. Both live and dead sea turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Hazel et al. 2007). Although sea turtles can move rapidly, they apparently are not adept at avoiding vessels that are moving at more than 4 km/hr; most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010). Hazel et al. (2007) suggested that green 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.

Portions of the Action Area are heavily traveled by commercial, recreational, and government marine vessels, with several commercial ports occurring in or near the Action Area. In the western Pacific Ocean, four waterways used by commercial vessels link Guam and the CNMI with major ports to both the east and west (Figure 46). Guam contains one commercial port located within Apra Harbor. The Port of Guam is the largest U.S. deepwater port in the Western Pacific and handles approximately two million tons (1,814,369,480 kg) of cargo a year (Port Authority of Guam 2011). The U.S. provides some 60 percent of Guam's imported goods, with the balance of Guam's trade coming from the Asian and Pacific markets of Japan, Taiwan, the Philippines, Hong Kong, and—to a lesser extent—Australia, New Zealand, and the islands of Micronesia (Port Authority of Guam 2011). Apra Harbor also provides economical transshipment services from Hawaii, and East Asia to the entire western Pacific. Most shipping lanes are located close to the coast but those that are trans-oceanic start and end to the northwest of Guam.

There are three ports within the CNMI. The Port of Rota, or Rota West Harbor, is located on the southwestern tip of the island and is classified as a very small port (World Port Source 2012a) that is mainly used for ferry boats. The Port of Tinian is described by the World Port Source as a small port offering excellent shelter, which allows relatively large vessels to dock there. The Port of Saipan is the largest and most advanced of the three ports, but is nevertheless described as a small seaport with poor shelter by the World Port Source. A number of facilities and services are available at the Port of Saipan, which transferred over 338,000 tons of cargo in 2009 (Commonwealth Ports Authority 2005; Commonwealth Ports Authority 2010).

Major commercial shipping vessels use the shipping lanes for shipping goods between Hawaii, the continental U.S., and Asia. However, there are no direct routes between Guam and the U.S.; stops are made in Asia, and usually Japan or Korea, before continuing on to either Hawaii or the continental U.S. The total number of vessels transiting through the Port of Guam has steadily decreased from 2,924 in 1995 to 1,022 in 2008 (DoN 2010a). The Port Authority of Guam estimates 635 total vessel calls, not counting naval ships, in 2013. The decrease is most pronounced in the number of barges and fishing vessels that transit through the port; however, the number of container ships has increased from a low of 103 in 2003 to a high of 165 in 2008.

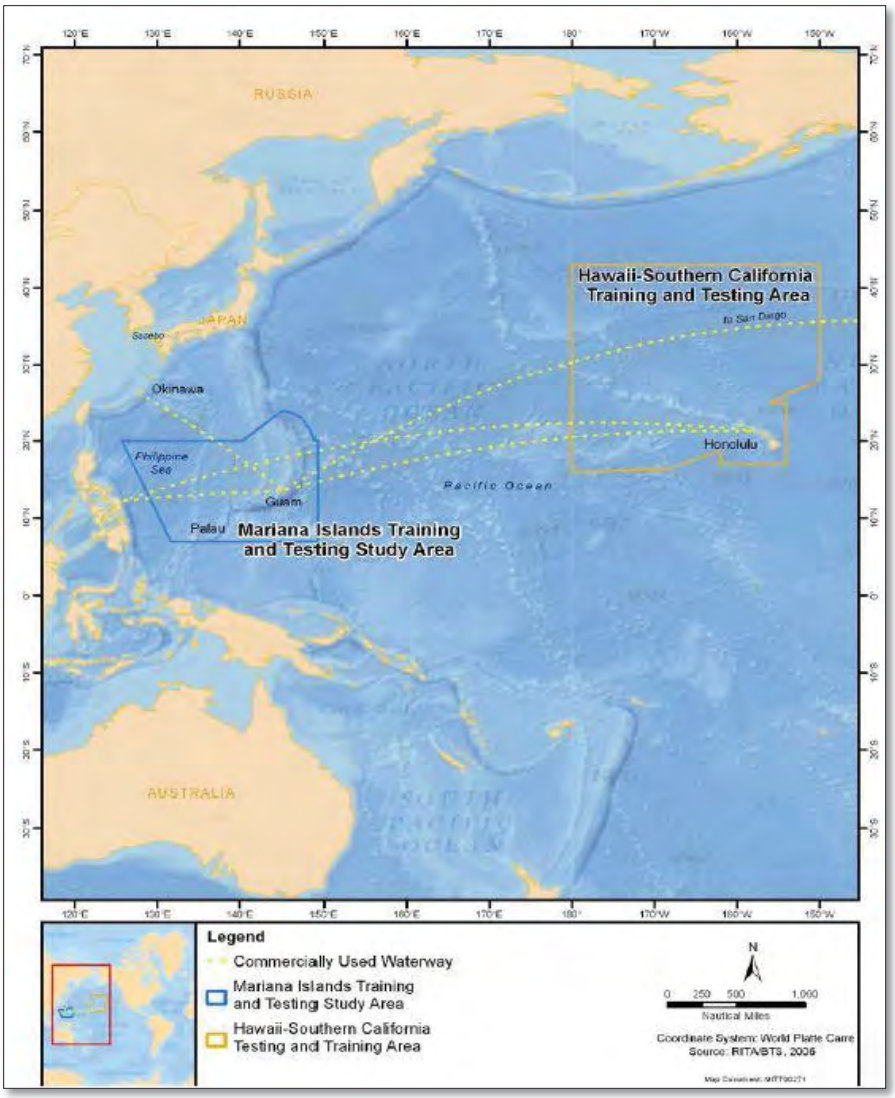


Figure 46: Shipping lanes in the action area.

The magnitude of the risk vessel strike poses to whales and sea turtles in the action area remains difficult to quantify or estimate. Information on ship strikes in Guam and the CNMI and in the offshore waters within the action area is virtually nonexistent. With the information available, we assume those interactions occur, but we cannot estimate their significance to populations of ESA-listed species. Although the Navy has a policy to report all ship strikes of whales, there has never been a documented case of a Navy vessel striking a whale (or any other ESA-listed animal) in the MITT Action Area over the many years testing and training activities have been conducted there.

7.10 Ocean Noise

A wide variety of anthropogenic and natural sources contribute to ocean noise throughout the world's oceans (Hatch and Wright 2007). Anthropogenic sources of noise that are most likely to contribute to increases in ocean noise are vessel noise from commercial shipping and general vessel traffic, oceanographic research, oil and gas exploration, underwater construction, and naval and other use of sound navigation and ranging.

Any potential for cumulative impact should be put into the context of recent changes to ambient sound levels in the world's oceans as a result of anthropogenic activities. However, there is a large and variable natural component to the ambient noise level as a result of events such as earthquakes, rainfall, waves breaking, and lightning hitting the ocean as well as biological noises such as those from snapping shrimp, other crustaceans, fishes, and the vocalizations of marine mammals (Crawford and Huang 1999; Patek 2002).

A possible explanation for the rise in ambient noise is the increase in shipping noise. There are approximately 11,000 supertankers worldwide, each operating approximately 300 days per year, each producing constant broadband noise at typical source levels of 198 dB (Hildebrand 2004). Generally the most energetic regularly operated sound sources are seismic airgun arrays from approximately 90 vessels with typically 12–48 individual guns per array, firing about every ten seconds (Hildebrand 2004).

Seismic surveys are typically conducted by towing a sound source behind a research vessel, such as an airgun array that emits acoustic energy in timed intervals. The transmitted acoustic energy is reflected and received by an array of hydrophones. This acoustic information is processed to provide information about geological structure below the seafloor. The oil and gas industry conduct seismic surveys to search for new hydrocarbon deposits. In addition, research geologists conduct seismic surveys to study plate tectonics as well as other topics in marine geology. The underwater sound produced by seismic surveys could affect marine life, including ESA-listed marine species. There are no current MMPA authorizations for seismic surveys in the action area.

Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. As described in greater detail later in this opinion, noise may cause marine mammals to leave a habitat, impair their ability to communicate, or to cause stress. Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury and, in some cases, may result in behaviors that ultimately lead to death. The severity of these impacts can vary greatly between minor impacts that have no real cost to the animal, to more severe impacts that may have lasting consequences. A comprehensive discussion of the potential impacts of ocean noise on listed species is included in the *Effects of the Action* section of this opinion (Section 8).

Very little data is available on ocean noise and its impacts on listed species in the action area. The extent of commercial and recreational shipping in the action area, which directly influences the extent of ocean noise in a given area, is described above. The extent of noise-producing activities associated with U.S. Navy training and testing in the action area is described in detail in the *Effects of the Action* section of this opinion.

It is clear that impacts to ESA-listed species may result from increased levels of anthropogenic-induced background noise or high intensity, short-term anthropogenic sounds within the action area. The majority of impacts have likely resulted in short-term behavioral responses of animals, although more serious impacts could have occurred. Despite the potential for these impacts to affect individual animals within the action area, information is not currently available to determine the potential population level effect of anthropogenic sound levels in the marine environment (MMC 2007) on ESA-listed marine mammals and sea turtles throughout their ranges. More information is needed, such as empirical data on how sound impacts an individual's growth and vital rates, how these changes impact that individual's ability to reproduce successfully, and then the relative influence of that individual's reproductive success on the population being considered. As a result, the consequences of anthropogenic sound on threatened and endangered marine mammal and sea turtles within that Action Area and at the population or species scale remain uncertain.

7.11 Scientific Research and Permits

Regulations for Section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies on ESA-listed species in the Pacific Ocean, some of which occur in portions of the Action Area. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, exposure to acoustic activities, and breath sampling. Research activities involve non-lethal "takes" of these whales. As of October 2, 2019, there were 21 permits in the Pacific Ocean authorizing research on one or more ESA-listed species considered in this opinion. Of those 21 permits, four authorized takes on ESA-listed whales that are sub-lethal. Sea turtle research (as of October 2, 2019) comprised five of those 21 permits and include capture, handling, restraint, tagging, biopsy, blood sampling, lavage, ultrasound, and tetracycline injection. All authorized take of sea turtles is sub-lethal. Therefore, ESA-listed species are encountering potential stress periodically within the action area as a result of the authorized scientific research.

7.12 Strandings

When a cetacean or sea turtle (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). A stranding can also occur away from the shore if the animal is unable to cope in its present situation (e.g. disabled by a vessel strike, out of habitat;

Geraci and Lounsbury, 2005). As discussed above (Section 7.5.1), bycatch studies are often compromised by limited data, lack of spatial coverage, and difficulty estimating the effects of post-capture mortality or reduced fitness (Lewison et al. 2004; Tomás et al. 2008). Supplemental information regarding the effects of bycatch and other potential threats on cetaceans and sea turtles can be derived from strandings data.

Cetaceans are subjected to a variety of natural and anthropogenic factors acting alone or in combination that may cause animals to strand (Geraci et al. 1999; Geraci and Lounsbury 2005). Natural factors related to strandings include limited food availability or following prey inshore, predation, disease, parasitism, natural toxins, echolocation disturbance, climatic influences, and aging (Culik 2004; Geraci et al. 1999; Geraci and Lounsbury 2005; Huggins et al. 2015; NRC 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors include pollution (Hall et al. 2006; Jepson et al. 2005a), vessel strike (Geraci and Lounsbury 2005; Laist et al. 2001), fisheries interactions (Read et al. 2006), entanglement (e.g., Saez et al. 2013; Saez et al. 2012), human activities (e.g., feeding, gunshot) (Dierauf and Gulland 2001; Geraci and Lounsbury 2005), and noise (Cox et al. 2006; Richardson et al. 1995b). For some stranding events, environmental factors (e.g., ocean temperature, wind speed, and topographic conditions) can be utilized in predictive models to aid in understanding why cetaceans strand in certain areas more than others (Berini et al. 2015). In most instances, even for the more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for strandings remains undetermined.

Sonar use during exercises involving the U.S. Navy has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Cox et al. 2006; Fernandez et al. 2006; Navy 2017c). These five mass strandings have resulted in about 40 known cetacean deaths consisting mostly of beaked whales (not ESA-listed) and with potential linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a potential indirect cause of death of the cetaceans (Cox et al. 2006). Strandings of other cetacean species have not been as closely linked to sonar exposure, but rather, have typically been attributed to natural or anthropogenic factors other than sonar. Multiple hypotheses regarding the relationship between non-impulsive sound exposure and stranding have been proposed. These range from direct impact of the sound on the physiology of the cetacean, to behavioral reactions contributing to altered physiology (e.g., “gas and fat embolic syndrome” (Fernandez et al. 2005a; Jepson et al. 2005b), to behaviors directly contributing to the stranding (e.g., beaching of fleeing animals). Unfortunately, without direct observation of not only the event but also the underlying process, and the potential for artefactual evidence (e.g. chronic condition, previous injury) to complicate conclusions from the post-mortem analyses of stranded animals (Cox et al. 2006), it has not been possible to determine with certainty the exact mechanism underlying these strandings. An in-depth discussion of strandings

can be found in the Navy's Technical Report on *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (Navy 2017c).

Historically, stranding reporting and response efforts have been inconsistent, although they have improved considerably over the last 25 years. While the investigation of stranded animals provides insight into the types of threats cetacean populations face, investigations are only conducted on a small fraction of the total number of strandings that occur, limiting our understanding of the causes of strandings (Carretta et al. 2016). Because of this, the current ability to interpret long-term trends in cetacean stranding is limited. However, through January 2019, nine beaked whales stranding events were reported in the Mariana Islands (Guam and Saipan), with the first recorded stranding in 2007. All identified beaked whales were Cuvier's beaked whales. Stranding events consisted of 1-3 animals. A tenth event, and most recent stranding (live) event of a Cuvier's beaked whale, occurred in November 2019 on Rota (Commonwealth of the Northern Mariana Islands). A review of Navy records indicates that sonar use occurred within 72 hours or 80 NM of three of these stranding events (2011, 2015, and 2016) (C. Johnson, Navy, personal communication with S. Egger, NMFS 2019). Several recent stranding events involving beaked whale species and overlapping Navy MFAS are discussed in (Simonis et al. 2020). In their study, Simonis et al. (2020) compared the history of known naval operations and beaked whale stranding events in the Mariana Archipelago to consider potential threats to beaked whale populations. They found that between June 2006 and January 2019 eight beaked whale stranding events occurred with one to three animals each and showed that half of these strandings occurred during or within six days after navy activities and was statistically significant. The strandings associated with the December 2018 to January 2019 exercise were later removed from the analysis since no MFAS was used during this exercise. However, when these strandings were removed from the analysis there was only a one percent chance that three of the eight stranded animals that occurred within six days after MFAS operations occurred by chance (Simonis et al. 2020).

Since 1962 there have been six recorded strandings of sperm whales in the action area (one stranding in 1962, 2011, 2012, and 2013 and two in 1993). We are not aware of any other reported strandings of ESA-listed cetaceans in the action area.

Summers et al. (2018a) summarized more than a decade of stranding recoveries (live and dead turtles) on the islands of Saipan and Tinian to obtain baseline information on the primary threats to sea turtles in the CNMI. Of the 89 sea turtle stranding records, 82 were green sea turtles (20 reported as live, 62 as dead) and five were hawksbill sea turtles (two of which were recovered live, three dead). Most of the identified sea turtles were females; although sex was undetermined for the vast majority (16 female, 5 male, and 61 undetermined), and most were juveniles (65 juveniles, 14 adults, and three of unknown age class). Summers et al. (2018a) noted that, of the 20 green turtles recovered live, 17 showed gross evidence of butchery, spear gun injuries, large stainless-steel hooks found embedded in the ventral neck region, and evidence of binding and

immobilizing individual sea turtles. Two of the three remaining live recoveries showed evidence of recent boat strike, and the third was a hatchling that was reportedly kept as a pet. For the green turtles recovered dead, Summers et al. (2018a) report mortality resulted for 48 of the 62 green turtles from the same activities noted for the recovered live turtles. Four of the five hawksbill turtle strandings from this study were the result of human interactions, including individuals recovered with spear gun injuries, butchered, or used as ornamental decorations, with one animal entangled in marine debris.

Data provided by the PIFSC for 2018 sea turtle strandings around Guam have shown six green sea turtles have been reported and one olive ridley. Of these seven strandings only one turtle (green, captured as an illegal harvest) was returned alive. Suspected causes for the strandings were plastic ingestion (1), illegal harvest (1), unknown (2), and vessel strikes (3, all in Apra Harbor).

8 EFFECTS OF THE ACTION ON SPECIES AND CRITICAL HABITAT

Section 7 regulations define "effects of the action" as all consequences to ESA-listed species or designated critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed 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 (50 C.F.R. §402.02). Section 7 regulations (50 C.F.R. §402.17) elaborate on this definition as follows:

- *Activities that are reasonably certain to occur* - A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available. Factors to consider when evaluating whether activities caused by the proposed action (but not part of the proposed action) or activities reviewed under cumulative effects are reasonably certain to occur include, but are not limited to: (1) Past experiences with activities that have resulted from actions that are similar in scope, nature, and magnitude to the proposed action; (2) Existing plans for the activity; and (3) Any remaining economic, administrative, and legal requirements necessary for the activity to go forward.

- *Consequences caused by the proposed action* - To be considered an effect of a proposed action, a consequence must be caused by the proposed action (i.e., the consequence would not occur but for the proposed action and is reasonably certain to occur). A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available. Considerations for determining that a consequence to the species or critical habitat is not caused by the proposed action include, but are not limited to: (1) The consequence is so remote in time from the action under consultation that it is not reasonably certain to occur; or (2) The consequence is so geographically remote from the immediate area involved in the action that it is not reasonably certain to occur; or (3) The consequence is only reached through a lengthy causal chain that involves so many steps as to make the consequence not reasonably certain to occur.

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The destruction and adverse modification analysis considers whether the action produces "a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 C.F.R. 402.02).

Previously in Section 5, we identified the potential stressors created by the Navy's testing and training activities. This section begins with a summary table (Table 58 below) of our effects determinations by stressor category for each ESA-listed species considered during this consultation. This serves as a cross reference for the sections to follow that provide the analyses supporting these effects determinations. This table also lists the overall effects determination for each species.

Recall that in Section 6, we provided a complete list of ESA-listed species and designated critical habitat that may be affected by the proposed action. Further, in Section 6.1, we explained that some ESA-listed species were not likely to be adversely affected by any of the stressors associated with the proposed action (labeled as "NLAA" in Table 58). This is because any effects on these species were extremely unlikely to occur such that they were discountable, or the size or severity of the impact was so low as to be insignificant, including those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. The ESA-listed species addressed in Section 6.1 are included in the summary table below because this table reflects all species considered during consultation. However, ESA-listed species determined in Section 6.1 to not likely be adversely affected by any of the stressors associated with the proposed action are not discussed further in this section of the opinion as there is no meaningful potential for the proposed action to affect their survival or recovery and thus no potential for the proposed action to result in jeopardy to these species.

In this section, we focus on those species that are *likely to be adversely affected* by one or more stressors associated with the proposed action. This section is organized by taxa (i.e., marine mammals, sea turtles, fish, and corals) since the species within each taxa often respond to stressors in similar ways. In Section 8.1, we discuss the stressors associated with the proposed action that we determined are *not likely to adversely affect* all species from a particular taxa (labeled as "NLAA" in Table 58). We do not carry these stressors forward in our effects analysis for that taxa since there is no meaningful potential for these stressors to affect the survival or recovery of species within the particular taxa. Finally, in Section 8.2, we summarize our analysis for the stressors and taxa (i.e., marine mammals, sea turtles, fish, and corals) combinations that are likely to result in adverse effects to some or all of the species within the taxa (labeled as "LAA" in Table 58). Cells labeled as "NE' in Table 58 indicate that we anticipate the stressor would have "no effect" on the species; these stressors were not included in our effects analysis for those particular species.

Table 58. NMFS ESA effects determinations by stressor for each ESA-listed species, and overall effects determination for each species (LAA = likely to adversely affect; NLAA = not likely to adversely affect; NE = no effect).

		Acoustic Stressors				*Explosive Stressors*	*Energy Stressors*		*Physical Disturbance and Strike Stressors*				*Entanglement Stressors*		*Ingestion Stressors*		
ESA-Listed Species	***Overall Determination***	***Sonar & Other Transducers***	***Vessel Noise***	***Aircraft Noise***	***Weapons Noise***	***Explosions***	***In-Water Electromagnetic Devices***	***High Energy Lasers***	***Vessels & In-Water Devices***	***Military Expended Material***	***Seafloor Devices***	***Personnel Disturbance***	***Wires & Cables***	***Decelerators / Parachutes***	***Military Expended Materials – Munitions***	***Military Expended Materials – Other than Munitions***	***Secondary Stressors***
Cetaceans																	
Blue whale	LAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Fin whale	LAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Humpback whale - Western N. Pacific DPS	LAA	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Sei whale	LAA	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Sperm whale	LAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Sea Turtles																	
Olive ridley turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Green turtle – Central West Pacific DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	LAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Green turtle – Central North Pacific DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	LAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Green turtle - East Indian-West Pacific DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Hawksbill turtle	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	LAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Leatherback turtle	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA

Loggerhead turtle – North Pacific DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Fish																	
Scalloped hammerhead shark – Indo-West Pacific DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Giant manta ray	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Oceanic whitetip shark	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA
Corals																	
Acropora retusa	NLAA	NE	NE	NE	NE	NLAA	NE	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Seriatopora aculeate	NLAA	NE	NE	NE	NE	NLAA	NE	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Acropora globiceps	LAA	NE	NE	NE	NE	LAA	NE	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

8.1 Stressors Not Likely to Adversely Affect ESA-Listed Species

Our analysis of the stressors created by the proposed action led to the determination that some stressors are not likely to adversely affect some or all ESA-listed species because the effect of that stressor would be insignificant or discountable. The following section discusses stressors that are not likely to adversely affect some or all ESA-listed species considered in this opinion. For analysis of effects to ESA-listed species, note that discussion in this section is organized by taxa (i.e., marine mammals, sea turtles, fish, coral) because the pathways for effects for these stressors is generally the same by taxa and we would not expect different effects at the species level. While there is variation among species within each taxa, the species within each taxa share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action.

8.1.1 Cetaceans

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed blue whales, fin whales, Western North Pacific DPS humpback whales, sei whales, or sperm whales. Our analysis for these stressors and cetaceans is summarized below.

Acoustic Stressors – Cetaceans

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed cetaceans. Additional discussion of the acoustic stressors associated with the proposed action is included in Section 5.1 above. The effects of additional acoustic stressors, which NMFS determined are likely to adversely affect cetaceans, are discussed in Section 8.2.1.

<u>Effects of Vessel Noise on Cetaceans</u>

Numerous studies of interactions between surface vessels and cetaceans have demonstrated that cetaceans engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two. However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of cetaceans to surface vessels are similar to their behavioral responses to predators. Based on studies of cetacean behavior to vessel approaches, several variables determine whether cetaceans are likely to be disturbed by surface vessels. The behavioral repertoire cetaceans have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal's assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal's flight initiation distance) (Sims et al. 2012). Below a threshold number of vessels (which probably varies from one species to another,

although groups of cetaceans probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior. Above that threshold, studies have shown that cetaceans will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (Bryant et al. 1984; David 2002; Kruse 1991; Lusseau 2003; Nowacek et al. 2001; Stensland and Berggren 2007; Williams and Ashe 2007);

The distance between vessel and cetaceans when the animal perceives that an approach has started and during the course of the interaction can affect whether cetaceans are likely to be disturbed by surface vessels (Au and Perryman 1982; David 2002; Hewitt 1985; Kruse 1991; Lundquist et al. 2012; Lusseau 2003; Tseng et al. 2011). Cetaceans are also more likely to respond to an approaching vessel when the vessel stays on a single or predictable path (Acevedo 1991; Angradi et al. 1993; Browning and Harland. 1999; Lusseau 2003; Lusseau 2006; Williams et al. 2002a) than when it engages in frequent course changes (Evans et al. 1994; Lusseau 2006; Williams et al. 2002a). Other studies have shown that noise associated with the vessel (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel's speed) affect how cetaceans react to vessels (David 2002; Lusseau 2003; Lusseau 2006; Polagye et al. 2011). The behavioral state of individual cetaceans at the time of a vessel approach can also determine whether or how the animal will react (David 2002; Lusseau 2003; Lusseau 2006; Wursig et al. 1998). For example, Würsig et al. (1998) concluded that whales were more likely to engage in avoidance responses when the whales were milling or resting than during other behavioral states.

Most of the investigations reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lundquist et al. 2012; Lusseau 2003; Lusseau 2004; Nowacek et al. 2001; Van Parijs and Corkeron 2001; Williams et al. 2002a; Williams et al. 2002b). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Baker and Herman 1989; Edds and Macfarlane 1987; Evans et al. 1992; Kruse 1991). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Although most of these studies focused on small cetaceans (for example, bottlenose dolphins, spinner dolphins, spotted dolphins, harbor porpoises, beluga whales, and killer whales), studies of large whales have reported similar results for fin and sperm whales (David 2002). Baker et al. (1983) reported that humpbacks in Hawaii responded to vessels at distances of 2 to 4 km. Richardson et al. (1985a) reported that bowhead whales (*Balaena mysticetus*) swam in the

opposite direction of approaching seismic vessels at distances between 1 and 4 km and engage in evasive behavior at distances under 1 km. Fin whales also responded to vessels at a distance of about 1 km (Edds and Macfarlane 1987).

In short-term studies, researchers have noted changes in resting and surface behavior states of cetaceans to whale watching vessels (Aguilar Soto et al. 2006; Arcangeli and Crosti 2009; Au and Green 2000; Christiansen et al. 2010; Erbe 2002b; Noren et al. 2009; Stensland and Berggren 2007; Stockin et al. 2008; Williams and Noren 2009). Noren et al. (2009) conducted research in the San Juan Islands in 2005 and 2006 and their findings suggested that close approaches by vessels impacted the whales' behavior and that the whale-watching guideline minimum approach distance of 100 meters may be insufficient in preventing behavioral responses. Most studies of this type are opportunistic and have only examined the short-term response to vessel sound and vessel traffic (Magalhaes et al. 2002; Noren et al. 2009; Richardson and Wursig 1995; Watkins 1981b). Fin whales may alter their swimming patterns by increasing speed and heading away from a vessel, as well as changing their breathing patterns in response to a vessel approach (Jahoda et al. 2003). Vessels that remained 328 ft. (100 m) or farther from fin and humpback whales were largely ignored in one study where whale watching activities are common (Watkins 1981a). Only when vessels approached more closely did the fin whales in this study alter their behavior by increasing time at the surface and exhibiting avoidance behaviors. Other studies have shown when vessels are near, some but not all fin whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Castellote et al. 2012; Williams et al. 2002b).

In the Watkins (1981a) study, humpback whales did not exhibit any avoidance behavior but did exhibit minor behavioral reactions to vessel presence. In a study of regional vessel traffic, Baker et al. (1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 1.24 and 2.48 mi (2,000 and 4,000 m) away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were within approximately 1.2 mi (2,000 m; (Baker and Herman 1983)). Similar findings were documented for humpback whales when approached by whale watch vessels in Hawaii (Au and Green 2000).

Gende et al. (2011) reported on observations of humpback whales in inland waters of Southeast Alaska subjected to frequent cruise ship transits (i.e., in excess of 400 transits in a 4-month season in 2009). The study was focused on determining if close encounter distance was a function of vessel speed. The reported observations, however, seem in conflict with other reports of avoidance at much greater distance so it may be that humpback whales in those waters are more tolerant of vessels (given their frequency) or are engaged in behaviors, such as feeding, that they are less willing to abandon. This example again highlights that context is critical for

predicting and understanding behavioral reactions as concluded by Southall et al. (2007) and Ellison et al. (2012).

Sei whales have been observed ignoring the presence of vessels and passing close to them (NMFS1993). In the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing, but otherwise do not exhibit strong reactions (Calambokidis et al. 2009a). Minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 nm; however, when the vessel drifted or moved at very slow speeds (about one knot), many whales approached it (Leatherwood et al. 1982).

Although not expected to be in the MITT Action Area, North Atlantic right whales tend not to respond to the sounds of oncoming vessels (Nowacek et al. 2004), and therefore might provide insight to behavioral responses of other baleen whales with the same hearing frequencies. North Atlantic right whales continue to use habitats in high vessel traffic areas (Nowacek et al. 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves (Nowacek et al. 2004; Terhune and Verboom 1999). Although this may minimize potential disturbance from passing ships, it does increase the whales' vulnerability to potential ship strike.

Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957 through 1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more 'uninterested' reactions towards the end of the study. Fin whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 98.4 ft. (30 m). Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986).

Sperm whales generally react only to vessels approaching within several hundred meters; however, some individuals may display avoidance behavior, such as quick diving (Magalhaes et al. 2002; Wursig et al. 1998). One study showed that after diving, sperm whales showed a reduced timeframe from when they emitted the first click than before vessel interaction (Richter et al. 2006). Small whale-watching and research vessels generate more noise in higher frequency bands and are more likely to approach odontocetes directly, and to spend more time near the individual whale. Reactions to Navy vessels are not well documented, but smaller whale-watching and research boats have been shown to cause these species to alter their breathing intervals and echolocation patterns.

Masking occurs when one sound (i.e., noise), interferes with the detection, discrimination, or recognition of another sound (i.e., signal). The quantitative definition of masking is the amount in dBs 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) (Navy 2019e). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, or changing frequency) and behavior changes (e.g., cessation of foraging, leaving an area) to both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al. 2016). Masking is more likely to occur in the presence of broadband, relatively continuous noise sources such as vessels.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity (Holt et al. 2008) as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). Likewise, modification of multiple vocalization parameters has been shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales off the northwestern coast of the U.S. have been observed to increase the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which has been suggested as a response to increased masking noise produced by the vessels (Foote et al. 2004). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. For example, the source level of killer whale vocalizations has been shown to increase with higher background noise levels associated with vessel traffic (Hotchkin and Parks 2013). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2008).

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. An increase in feeding call rates and repetition by humpback whales in Alaskan waters was associated with vessel noise (Doyle et al. 2008). Melcon et al. (2012) also recently documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Conversely, decreases in singing activity by humpback whales have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcon et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. Castellote et al. (2012) demonstrated that fin whales' songs had shortened duration and decreased bandwidth, center frequency, and peak frequency in the presence of high shipping noise levels. It is not known if these changes in vocal behavior corresponded to other behaviors. 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. 2007) as well as increasing the amplitude (intensity) of their calls (Parks 2009; Parks et al. 2011). However, Cholewiak et al. (2018) found that right whale gunshot calls had the lowest loss of communication space in Stellwagen National Sanctuary (5 percent), while fin and humpback whales lost up to 99 percent of their communication space with increased ambient noise and shipping noise combined. Although humpback whales off Australia did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected based on source level changes to wind noise, potentially indicating some signal masking (Dunlop 2016). Clark et al. (2009) estimated the noise from the passage of two vessels could reduce the optimal communication space for North Atlantic right whales by 84 percent (see also (Hatch et al. 2012).

The available information, as discussed above, suggests that ESA-listed cetaceans are either not likely to respond to vessel noise or are expected to respond only briefly if exposed to noise from Navy vessels. Expected behavioral responses include startle responses, brief avoidance behavior, changes in respiration rate, or changes in vocal patterns. Most avoidance responses would consist of slow movements away from vessels the animals perceive are on an approaching course, perhaps accompanied by slightly longer dives. Most of the changes in behavior would consist of a temporary shift from behavioral states that have low energy requirements (resting or milling) to behavioral states with higher energy requirements (active swimming or traveling) and then returning to the resting or milling behavior.

We expect individuals that exhibit a temporary behavioral response will return to baseline behavior immediately following exposure to the vessel noise. Long-term and cumulative impacts of vessel sound on cetaceans remains largely unknown. For behavioral responses to result in energetic costs that result in long-term harm, such disturbances would likely need to be sustained for a significant duration or extent where individuals exposed would not be able to select alternate habitat to recover and feed. Given the typical Navy training and testing activities involving vessels are not continuous year round in the action area, we do not expect prolonged vessel noise exposures and preclusion of individuals from feeding, breeding, or sheltering habitat. Exposure of marine species to vessel noise would be greatest in nearshore areas of highest vessel traffic, particularly around Apra Harbor. Cetacean densities in areas of high vessel activity within the MITT Action Area are expected to be very low. For these reasons, and given the short duration of vessel noise stressors and the infrequency of this stressor, we do not expect cetacean reactions to vessel noise to have any measurable effects on an individual's fitness and behavioral responses to vessel noise which would result in adverse effects.

In summary, ESA-listed cetaceans are either not likely to respond to Navy vessel noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Additionally, the effects of any temporary masking specifically from Navy vessels are expected to be of a short duration and not result in meaningful changes to an animals ability to communicate or detect biologically

relevant cues given the background noise levels in the action area independent of Navy vessels and the small percentage of vessel traffic Navy vessels represent in the action area (as discussed in Section 5.1.3 above). Based on this analysis, as stated, we conclude that such effects are not measurable. Therefore, the effects of vessel noise on ESA-listed cetaceans from Navy vessels are considered insignificant, and thus are not likely to cause adverse effects.

Effects of Aircraft Noise on Cetaceans

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. Additional discussion of aircraft overflight noise as a potential stressor is included in Section 5.1.4. Thorough reviews of the subject and available information is presented in Richardson (1995) and elsewhere (e.g., Efroymson et al. 2001; Holst et al. 2011; Luksenburg and Parsons 2009; Smith et al. 2016).

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone (Navy 2017b). Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. Cetaceans may respond to both the physical presence and to the noise generated by aircraft, making it difficult to attribute causation to one or the other stimulus. In addition to noise produced, all low-flying aircraft make shadows, which can cause animals at the surface to react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal's behavior at or near the surface.

The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping; Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Holst et al. 2011; Manci et al. 1988). Richardson et al. (1995b) noted that marine mammal reactions to aircraft overflights have largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition, it was suggested that variations in the responses noted were generally due to other undocumented factors associated with overflights (Richardson et al. 1995b). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (altitude, centered on the animal, off to one side, circling, level and slow), environmental factors (e.g., wind speed, sea state, cloud cover) and locations where native subsistence hunting continues and animals are more sensitive to anthropogenic impacts, including the noise from aircraft. Christiansen et al. (2016a) measured the in air and underwater noise levels of two unmanned aerial vehicles. The researchers found that in air the broadband source levels were around 80 dB re 20 μPa, while at a meter underwater received levels were 95 to 100 dB re 1 μPa when the vehicle was only 5 to 10 m above the surface, and were not quantifiable above ambient noise levels when the vehicle was higher. Therefore, if an animal is

near the surface and the unmanned aerial vehicle is flying at a low altitude, it may be detected, but in most cases these vehicles are operated at much higher altitudes (e.g. well over 30 m) and are not likely to be heard.

The impact of aircraft overflights is one of the least well-known sources of potential behavioral response by any species or taxonomic group, and so many generalities must be made based on the little data available. There is some data for each taxonomic group; taken together it appears that in general, cetaceans have varying levels of sensitivity to overflights depending on the species and context. Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998). Richardson et al. (1985b) and Richardson et al. (1995a) 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. 1985b). 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 beluga whales in the same area (Patenaude et al. 2002). It should be noted that bowhead whales in this study may have more acute responses to anthropogenic activity than many other cetaceans because these animals were presented with restricted egress due to limited open water between ice floes. Additionally, these animals are hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

A pilot study was conducted on the use of unmanned aerial vehicles to observe bowhead whales. Flying at altitudes between 120 to 210 m above the surface, no behavioral responses were observed in any animals (Koski et al. 2015; Koski et al. 1998). Similarly, Christiansen et al. (2016a) did not observe any responses to an unmanned aerial vehicle flown 30 to 120 m above the water when taking photos of humpback whales to conduct photogrammetry and assess fitness. Acevedo-Whitehouse et al. (2010) successfully maneuvered a remote-controlled helicopter over large baleen whales to collect samples of their blows, with no more avoidance behavior than noted for typical photo-identification vessel approaches. Unmanned aircraft are much smaller and quieter than typical aircraft and so are less likely to cause a behavioral response, although they may fly at much lower altitudes (Smith et al. 2016).

During standard marine mammal surveys at an altitude of 750 ft, some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Richter et al. 2006; Smultea et al. 2008; Wursig et al. 1998). In one study, sperm whales showed no reaction to a helicopter until

they encountered the downdrafts from the rotors (Richardson et al. 1995b). 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).

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 cetaceans, the slower airspeed and therefore potentially longer exposure duration, and the downdraft created by the helicopter's rotor. Cetaceans 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 Navy aircraft typically transit open ocean areas within the action area. The literature cited above indicates that aircraft noise would cause only small temporary, short-term behavioral changes. Specifically, cetaceans at or near the surface when an aircraft flies overhead at low altitude may startle, divert their attention to the aircraft, or avoid the immediate area by swimming away or diving.

It should be noted that many of the observations cited in this section are of marine mammal reactions to aircraft flown for whale-watching and cetacean research purposes. Marine mammal survey aircraft are typically used to locate, photograph, track, and sometimes follow animals for long distances or for long periods of time, all of which results in the animal being much more frequently located directly beneath the aircraft (in the cone of the loudest noise and potentially in the shadow of the aircraft) for extended periods. In contrast, Navy aircraft would not follow cetaceans so Navy activities would not result in prolonged exposure of cetaceans to overhead noise or encroachment.

To summarize, in most instances, exposure of a cetacean to fixed-wing aircraft, helicopters, and unmanned aircraft presence and noise would last for only seconds as the aircraft quickly passes overhead. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields as well as on vessels at sea at unspecified locations across the Action Area. Takeoffs and landings from Navy vessels could startle cetaceans. 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 also startle cetaceans, but these events are transient and happen infrequently at any given location within the action area. Repeated exposure to most individuals over short periods (days) is extremely unlikely, except for animals that are resident in inshore areas around Navy ports, on Navy fixed ranges, or during major training exercises. Resident animals could be subjected to multiple overflights per day, though most of the ESA-listed cetaceans considered in this opinion have wide ranging life histories. Additionally, aircraft would pass quickly overhead, typically at altitudes above 3,000 ft, which would make cetaceans unlikely to respond.

In summary, ESA-listed cetaceans are either not likely to respond to Navy aircraft noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Due to the short term and infrequent nature of any exposures, and the brief and inconsequential behavioral responses of animals that could follow such exposure, the effects of aircraft overflight noise from Navy activities on ESA-listed cetaceans is considered insignificant, and thus are not likely to cause adverse effects.

Effects of Weapons Firing, Launch, and Impact Noise on Cetaceans

Activities using weapons and deterrents would be conducted as described in Section 3 of this opinion. Additional discussion on weapons noise as a potential stressor is included in Section 5.1.5. The use of weapons during training could occur almost anywhere within the action area. Noise associated with large caliber weapons firing and the impact of non-explosive practice munitions or kinetic weapons would typically occur at locations greater than 12 NM from shore for safety reasons. Small- and medium-caliber weapons firing could occur throughout the Action Area.

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle into the water. Yagla and Stiegler (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 μPa. Animals at the surface of the water, in a narrow footprint under a weapons trajectory, could be exposed to naval gunfire noise and may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. These sounds would be transient and of short duration, lasting no more than a few seconds at any given location. Additionally, due to the short-duration, transient nature of launch noise, cetaceans are unlikely to be exposed multiple times within a short period.

Although missiles are launched from aircraft, they are expected to 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 cetaceans 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. Cetaceans 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.

In summary, ESA-listed cetaceans are either not likely to respond to Navy weapons noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. If they do occur, behavioral reactions would likely be short-term (seconds to minutes) and multiple exposures of the same animal over a short duration are not anticipated. For these reasons, the effects of

weapons noise from Navy activities on ESA-listed cetaceans are considered insignificant, and thus are not likely to cause adverse effects.

Effects of Explosions in Air on Cetaceans

Explosions that occur during air warfare would typically be at sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude and would not reach the water's surface where ESA-listed species could occur. Cetaceans within the audible range of sound from explosions in air may exhibit a behavioral startle response but are expected to quickly return to normal behavior. Due to the short duration and sporadic nature of explosions in the air, and the extremely low likelihood of an ESA-listed cetacean being within close enough proximity to detect sounds from such explosions, we do not expect any temporary behavioral responses to result in a significant disruption of breeding, feeding, or sheltering of individual animals. Effects are unlikely to be measureable. Therefore, the effects of sound from explosions in air during Navy activities on ESA-listed cetaceans are considered insignificant, and thus are not likely to cause adverse effects.

Effects of Nitrogen Decompression and Acoustically-induced Bubble Formation due to Sonar Exposures

In this section we discuss two potential effects resulting from exposure to Navy sonar in the action area that we determined are not likely to adversely affect ESA-listed cetaceans. These are nitrogen decompression and bubble formation that may occur in blood and other tissue of an animals exposed to this stressor. In Section 8.2.1, we discuss all other effects resulting from Navy sonar exposure that are likely to adversely affect ESA-listed cetaceans in the action area.

Nitrogen Decompression

Cetaceans are thought to deal with nitrogen loads in their blood and other tissues, caused by gas exchange from the lungs under conditions of high ambient pressure during diving, through anatomical, behavioral, and physiological adaptations (Hooker et al. 2012). Although not a direct injury, variations in cetacean diving behavior or avoidance responses could result in nitrogen off-gassing in super-saturated tissues, possibly to the point of deleterious vascular and tissue bubble formation (Hooker et al. 2012; Jepson et al. 2003; Saunders et al. 2008) with resulting symptoms similar to decompression sickness (also known as "the bends" in humans).

The process has been under debate in the scientific community (Hooker et al. 2012; Saunders et al. 2008), although analyses of by-caught and drowned animals has demonstrated that nitrogen bubble formation can occur once animals are brought to the surface and tissues are supersaturated with nitrogen (Bernaldo De Quiros et al. 2013; Moore et al. 2009). Deep diving whales, such as beaked whales (not listed under the ESA), normally have higher nitrogen loads in body tissues, which may make them more susceptible to decompression for certain modeled changes in dive behavior (Fahlman et al. 2014b; Fernandez et al. 2005a; Hooker et al. 2012; Jepson et al. 2003).

Researchers have examined how dive behavior affects tissue supersaturation conditions that could put an animal at risk of gas bubble embolism. An early hypothesis was that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernandez et al. 2005a; Jepson et al. 2003). However, modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al. 2005a; Jepson et al. 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Hooker et al. 2012; Tyack et al. 2006; Zimmer and Tyack 2007). Longer times spent diving at mid-depths above lung collapse would allow gas exchange from the lungs to continue under high hydrostatic pressure conditions, increasing potential for supersaturation; below the depth of lung collapse, gas exchange from the lungs to the blood would likely not occur (Fahlman et al. 2014b). However, Costidis and Rommel (2016) suggest that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes (e.g., sperm whales) below the depth of lung collapse if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins, contributing to tissue gas loads. To examine the potential for gas bubble formation, a bottlenose dolphin was trained to dive repetitively to depths shallower than lung collapse to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2009).

To estimate risk of decompression sickness, Kvadsheim (2012) modeled gas exchange in the tissues of sperm, pilot, killer, and beaked whales based on actual dive behavior during exposure to sonar in the wild. Results indicated that venous supersaturation was within the normal range for these species, which have naturally high levels of nitrogen loading. Researchers have also considered the role of accumulation of carbon dioxide produced during periods of high activity by an animal, theorizing that accumulating carbon dioxide, which cannot be removed by gas exchange below the depth of lung collapse, may facilitate the formation of bubbles in nitrogen saturated tissues (Bernaldo De Quiros et al. 2012; Fahlman et al. 2014b). Garcia Parraga et al. (2018) suggest that diving marine mammals have physiological and anatomical adaptations to control gas uptake above the depth of lung collapse, favoring oxygen uptake while minimizing nitrogen uptake. Under the hypothesis of Garcia Parraga et al. (2018), elevated activity due to a strong evasive response could lead to increased uptake of nitrogen, resulting in an increased risk of nitrogen decompression.

Modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (i.e., tissues that take longer to give off nitrogen, e.g., fat and bone lipid) to the point that they are supersaturated when the animals are at the surface (Fahlman et al. 2014b; Hooker et al. 2009; Saunders et al. 2008). The presence

of osteonecrosis (bone death due to reduced blood flow) in deep diving sperm whales has been offered as evidence of chronic supersaturation (Moore and Early 2004). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation in these tissues has been demonstrated in marine mammals drowned at depth as fisheries bycatch and brought to the surface (Moore et al. 2009). For beaked whale strandings associated with sonar use, one theory is that observed bubble formation may be caused by long periods of compromised blood flow caused by the stranding itself (which reduces ability to remove nitrogen from tissues) following rapid ascent dive behavior that does not allow for typical management of nitrogen in supersaturated, long-halftime tissues (Houser et al. 2009).

A fat embolic syndrome (out of place fat particles, typically in the bloodstream) was identified by Fernandez et al. (2005b) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream.

Dennison et al. (2011) reported on investigations of dolphins stranded in 2009 to 2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the liver of two of the 22. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed could be tolerated since the majority of stranded dolphins released did not re-strand.

The appearance of extensive bubble and fat emboli in beaked whales (not listed under the ESA) is unique to strandings associated with certain high intensity sonar events. The phenomenon has not been observed in other stranded cetaceans, nor has it been observed in beaked whale strandings not associated with sonar use. It is not clear whether there is some mechanism for this phenomenon specific to beaked whales or whether the phenomenon occurs only following rapidly occurring stranding events (i.e., when whales are not capable of sufficiently decompressing). Because of the lack of evidence for extensive nitrogen bubble formation while diving, NMFS believes that the probability of ESA-listed cetaceans getting “the bends” following sonar acoustic exposure to be extremely low, and thus, discountable.

Acoustically-induced Bubble Formation Due to Sonars

A suggested cause of injury to cetaceans is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a microscopic gas bubble by exposing it to a sound field. The process is dependent upon a number of factors including the SPL and duration of exposure. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent that tissue hemorrhage (injury)

occurs, (2) bubbles develop to the extent that an immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lungs without negative consequence to the animal.

Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by cetaceans can cause the blood and some tissues to become supersaturated (Ridgway and Howard 1979). The dive patterns of some cetaceans (e.g., non-ESA listed beaked whales) are predicted to induce greater supersaturation (Houser et al. 2001a). If rectified diffusion were possible in cetaceans exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar pulses would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis, suggested by Crum et al. (2005), is that stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of supersaturated tissues. In such a scenario, the cetacean would need to be in a gas-supersaturated state for a long enough time for bubbles to reach a problematic size. The phenomena of bubble growth due to a destabilizing exposure was shown by Crum et al. (2005) by exposing highly supersaturated ex vivo bovine tissues to a 37 kHz source at 214 dB re 1 μPa. Although bubble growth occurred under the extreme conditions created for the study, these conditions would not likely exist in the wild because the levels of tissue supersaturation in the study (as high as 400–700 percent) are substantially higher than model predictions for cetaceans (Fahlman et al. 2009; Fahlman et al. 2014b; Houser et al. 2001a; Saunders et al. 2008). In addition, such high exposure levels would only occur in very close proximity to the most powerful Navy sonars. With the proposed Navy mitigation measures in place, it is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings. For these reasons we believe that ESA-listed cetacean injury resulting from acoustically induced bubble formation during Navy MITT activities to be extremely unlikely, and thus, discountable.

Effects of Other Acoustic Sources Not Quantitatively Analyzed

Several of the acoustic sources associated with MITT activities were not quantitatively analyzed in terms of their effects on ESA-listed species. These include the following: broadband sound sources; Doppler sonar; fathometers; hand-held sonar; imaging sonar; high-frequency acoustic modems; tracking pingers; acoustic releases; and side-scan sonars (see Table 22 above for details). When used during routine training and testing activities, and in a typical environment, these sources fall into one or more of the following categories:

- Transmit primarily above 200 kHz: Sources above 200 kHz are above the hearing range of the ESA-listed species in the action area.

- Source levels of 160 dB re 1 μPa or less: Low-powered sources with source levels less than 160 dB re 1 μPa are typically hand-held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB re 1 μPa source, the sound will attenuate to less than 140 dB re 1 μPa within ten meters (m) and less than 120 dB re 1 μPa within 100 m of the source. Ranges would be even shorter for a source less than 160 dB re 1 μPa source level. As discussed above (Section 2.2.2) we assume that cetaceans would not exhibit a behavioral response when exposed to such low source levels.
- Acoustic source classes listed in Table 22: Sources with operational characteristics, such as short pulse length, narrow beam width, downward-directed beam, and low energy release, or manner of system operation, which exclude the possibility of any significant impact on an ESA-listed species (actual source parameters are classified). Even if there is a possibility that some species may be exposed to and detect some of these sources, any response is expected to be short term and insignificant.

Therefore, these acoustic sources associated with MITT activities (as described in Table 22) would either have no effect on ESA-listed cetaceans, or the effects would be insignificant (and thus are not likely to cause adverse effects) depending on the particular source considered.

Effects of Explosive Sources Not Quantitatively Analyzed

In addition to the explosives quantitatively analyzed for impacts to ESA-listed species (shown in Table 23 above), the Navy uses some very small impulsive sources (less than 0.1 lb. NEW), categorized in bin E0, that were not quantitatively analyzed by the Navy for potential exposure to ESA-listed species. Quantitative modeling in multiple locations has indicated that these sources have a very small zone of influence. As such, it is extremely unlikely that ESA-listed cetaceans would be exposed to explosives in bin E0. Therefore, potential effects from explosives in bin E0 on ESA-listed cetaceans are discountable.

Energy Stressors – Cetaceans

This section analyzes the effects of energy stressors used during Navy training and testing activities on cetaceans within the action area. Additional discussion on energy stressors is included in Section 5.2. This section includes analysis of the potential impacts of: 1) in-water electromagnetic devices and 2) high-energy lasers.

Effects of In-water Electromagnetic Devices on Cetaceans

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. The sound and electromagnetic signature cause nearby mines to detonate. 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. Cetaceans appear to use the Earth's magnetic field for migration in two ways: as a map by moving parallel to the contours of the local field topography, and as a timer based on the regular fluctuations in the field allowing animals to monitor their progress on this map (Klinowska 1990).

Most of the evidence of cetaceans sensing magnetic fields is indirect evidence from correlation of sighting and stranding locations suggesting that cetaceans may be influenced by local variation in the earth's magnetic field (Kirschvink 1990; Klinowska 1985; Walker et al. 1992). Results from one study in particular showed that long-finned and short-finned pilot whales, striped dolphin, Atlantic spotted dolphin, Atlantic white-sided dolphin, fin whale, common dolphin, harbor porpoise, sperm whale, and pygmy sperm whale were found to strand in areas where the earth's magnetic field was locally weaker than surrounding areas. Results also indicated that certain species may be able to detect total intensity changes of only 0.05 microteslas (Kirschvink et al. 1986). This gives insight into what changes in intensity levels some species are capable of detecting, but does not provide experimental evidence of levels to which animals may physiologically or behaviorally respond.

Impacts to cetaceans 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 MITT activities are relatively weak (only ten percent of the earth's magnetic field at 24 m), temporary, and localized. Once the source is turned off or moves from the location, the electromagnetic field is gone. A cetacean 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 which would have an adverse effect on an individual animal. Given the small area associated with mine fields, the infrequency and short duration of magnetic energy use, the low intensity of electromagnetic energy sources (essentially mimicking the magnetic field of a steel vessel), the density of ESA-listed cetaceans in these areas, and the Navy's procedural mitigation measure to not approach ESA-listed cetaceans within 500 yds, NMFS considers it extremely unlikely that ESA-listed cetaceans 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 used during Navy activities are considered discountable.

Effects of Lasers on Cetaceans

High-energy laser weapons activities involve evaluating the effectiveness of an approximately 30-kilowatt high-energy lasers deployed from a surface ship or a helicopter to create small but critical failures in potential targets from short ranges. A cetacean could potentially be exposed to the laser beam at or near the water's surface, which could result in injury or death. However, cetaceans could only be exposed if the laser beam missed the target (i.e., if the laser hit the target, it would not be expected to penetrate the water and potentially impact an animal

underwater), which is not a common occurrence. Additionally, ESA-listed cetacean densities in the action area are relatively low.

The potential for cetaceans to be directly hit by a high-energy laser beam was evaluated by the Navy using statistical probability modeling to estimate the probability of direct strike exposures in a worst-case scenario. Model input values included high-energy laser use data (e.g., number of high-energy laser exercises and laser beam footprint), size of the training or testing area, marine mammal density data, and animal size. To estimate the probability of hitting a marine mammal in a worst-case scenario (based on assumptions listed below), the impact area for all laser training and testing events was summed over one year in each respective training or testing area. The marine mammal species with the highest average seasonal density within the action area was used in the analysis. All other species with a lower density would be expected to have a lower probability of being struck by the laser. Other conservative assumptions incorporated into the model are as follows:

- The model is two-dimensional and assumes that all animals would be at or near the surface 100 percent of the time.
- The model assumes the animal is stationary and does not account for any movement of the marine mammal or any potential avoidance of the training or testing activity.

The Navy's model estimates zero exposures for blue whales, fin whales, humpback whales, and sei whales, and 0.000001 exposures every year for sperm whales. Based on the very low number of annual exposures, the characteristics of activities that would use high-energy lasers (e.g., short range distance from source to target, high-precision targeting, short duration of the energized beam), and likely animal avoidance behavior of laser targets, NMFS considers it extremely unlikely that ESA-listed cetaceans would be exposed to high energy lasers. Therefore, potential effects from lasers during Navy activities are considered to be discountable.

Physical Disturbance and Strike Stressors – Cetaceans

This section analyzes the potential effects of physical disturbance and strike of ESA-listed cetaceans during MITT activities resulting from Navy vessels, in-water devices, and military expended materials (including non-explosive practice munitions and fragments from high-explosive munitions), and seafloor devices.

<u>Effects of Vessel Strike on Cetaceans</u>

Vessels used by the Navy during training and testing activities include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 ft to over 1,000 ft. Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than 40 ft. [12 m] in length), which are all support craft, have much more

variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of these parameters. There are a few specific events, including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the joint high speed vessel (which will operate at an average speed of 35 knots), where vessels would operate at higher speeds. Table 50 provides examples of the types of vessels, length, and speeds typically used in Navy testing and training activities.

The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately ten knots, with faster vessels, especially of large vessels (80 m or greater), being more likely to cause serious injury or death (Conn and Silber 2013; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. Injuries to whales killed by vessel strikes include huge slashes, cuts, broken vertebrae, decapitation, and animals cut in half (Carillo and Ritter 2010).

A recent study on humpback whales, reported that during their breeding season on the Great Barrier Reef, humpback females with a dependent calf had a higher risk of ship strike compared to groups without a calf (when sightings were standardized for group size) (Smith et al. 2020). Furthermore, their inshore movement and coastal dependence later in the breeding season increased their overlap with shipping traffic, even though their lower relative abundance (as compared to the larger groups without calves) decreased risk. This study emphasized the importance of reduced ship speeds in and around know breeding areas where humpback mother/calf associations occur (Smith et al. 2020).

In fact, speed restrictions are the most viable and economically feasible mitigation measure given that speed reductions (to less than or equal to ten knots) can significantly reduce the risk of ship strikes and reduce mortality (Smith et al. 2020; Vanderlaan and Taggart 2007). This is very important and applicable to the MITT Action Area given the recent evidence of known humpback whale breeding areas and the presence of mother/calf pairs on Marpi Reef and Chalan-Kanoa Reefs (north and west of Saipan, respectively)(Hill et al. 2020b).

Navy vessels represent a relatively small amount of overall vessel traffic in the action area. Over the 5-year period between 2014 and 2018, there were cumulatively 1,497 Navy vessel transits through Apra Harbor. This represents 14 percent of all vessel transits, or about six times less than commercial shipping. The annual average number of Navy vessel transits over the 5-year interval was 299 transits. Across all warfare areas and activities, the Navy estimates a total of 493 days (i.e., one day equals 24 hours) of at-sea time would occur annually within the MITT Action Area. Amphibious Warfare activities account for 60.7 percent of total surface ship days, MTEs account for 25.4 percent, Anti-Surface Warfare activities account for 8.4 percent, and Anti-Air Warfare, Anti-Submarine Warfare and other activities (sonar maintenance, anchoring) account for about two percent each (Navy 2019a).

The number of military vessels in the action area at any given time varies and is dependent on local training or testing requirements. Vessel movement as part of the proposed action would be widely dispersed throughout the Action Area, but more concentrated in portions of the Action Area near ports, naval installations, range complexes and testing ranges. Potential exposure of ESA-listed species to vessel strike, in general, would be greatest in the areas of highest vessel traffic in close proximity to ports. For most species, cetacean densities in areas of high Navy vessel activity within the MITT Action Area are expected to be very low. The exception to this would be humpback whale densities within the Marpi Reef and Chalan Kanoa Reef mitigation areas from December through May.

For the MITT Action Area, there is one port on Guam as well as Naval Base Guam, and three ports within the CNMI (Port of Rota, Port of Tinian, and Port of Saipan). Large hull civilian commercial ships and Navy ships are mostly associated with transits into and out of Apra Harbor on the southwest side of Guam. While the Navy ships assigned to any particular homeport change periodically, there are presently no Navy surface warships homeported in Guam. The types of vessels currently homeported in Apra Harbor include submarines, support vessels like a submarine tender and a military sealift (i.e., logistics) unit, and small vessels like coastal riverine craft.

The western approaches to Apra Harbor are the central corridor of vessel movements in the MITT Action Area, as visiting, transiting, homeported vessels pull in and out for port calls and resupply. Depending on a given exercise, many of the participating ships could use Apra Harbor prior to or after the event depending on operational schedules. A significant amount of Mine Warfare events with vessel movements would be more likely west of Guam and adjacent to Apra Harbor, depending on the event.

Navy vessels do not berth at any other locations (besides Apra Harbor) within the MITT Action Area. Within the CNMI, the Port of Rota is located on the southwestern tip of the island. It is a very small, poorly sheltered port with a pierside water depth of six to ten ft. which limits the size of vessels that can access the pier. The Port of Rota is mainly used for ferry boats transporting tourists and residents from its sister island, Tinian. The Port of Tinian is a small, well sheltered port. Mobil Oil operates a fuel plant at the port, and a ferry service transports tourists from Saipan to Tinian. The Port of Saipan is the largest of the three CNMI ports. The port of Saipan is on the southwest shore and houses commercial ships, small local boats or ferries, and military vessels.

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in training and testing may consist of a single vessel involved in unit-level activity for a few hours or multiple vessels involved in a major training exercise that could last a few weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration. Activities range from involving one or two vessels to several vessels operating over various time frames and

locations. Vessel movements in the action area fall into one of two categories; 1) those activities that occur in the offshore component of the Action Area and 2) those activities that occur in inshore waters.

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

The Navy employs several actions to minimize collisions between surface vessels and ESA-listed animals that might occur in the action area. These measures include lookouts and watchstanders on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales to alert other ships in the area. A mitigation measure for Navy vessels is to maneuver the vessel to maintain a distance of at least 500 yds (457 m) from any observed whale and to avoid approaching whales head-on, as long as safety of navigation is not imperiled. Other factors to consider when comparing the potential risk of Navy vessel strike of a cetacean to that of typical commercial vessels include the following:

- Many military ships have their bridges positioned closer to the bow, offering better visibility ahead of the ship (compared to a commercial merchant vessel).
- There are often aircraft associated with Navy training or testing activities, which can more readily detect cetaceans in the vicinity of a vessel or ahead of a vessel's present course before crew on the vessel would be able to detect them.
- Military ships are generally more maneuverable than commercial merchant vessels, and if cetaceans are spotted in the path of the ship, would be capable of changing course more quickly.
- The crew size on military vessels is generally larger than merchant ships, allowing for the possibility of stationing more trained Lookouts on the bridge. At all times when vessels are underway, trained Lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including cetaceans. Additional Lookouts, beyond those already stationed on the bridge and on navigation teams, are positioned as Lookouts during some training events.

Navy policy (Chief of Naval Operations Instruction F3100.6J) requires participating vessels to report all whale strikes. That information is collected by the Office of the Chief of Naval Operations Energy and Environmental Readiness Division and cumulatively provided to NMFS on an annual basis. The Navy and NMFS have standardized regional reporting protocols for communicating to NMFS stranding coordinators information on any ship strikes as soon as

possible. These communication procedures will remain in place as part of this proposed action. Recently, the Navy has reported a decreasing trend overall in large whale vessel strikes across all Navy Operating Areas since implementation of the Marine Species Awareness Training program in 2007. While other factors may have played a role, this suggests that the environmental awareness and education program may be contributing to the effectiveness of mitigation implementation.

While it is possible for a Navy vessel to strike a cetacean during the course of training and testing activities in MITT Action Area, we do not believe this is likely to occur during Navy activities from Navy vessels. As stated previously, the Navy has been training in the action area for years and no such incident has occurred. Additionally, the Navy employs minimization measures to reduce the likelihood for a surface vessel to strike a large whale. For these reasons, while it is possible, we consider it extremely unlikely that an ESA-listed cetacean would be struck by a vessel during Navy training and testing activities in the MITT Action Area, and thus the effects of vessel strike are discountable.

Effects of In-water Devices on Cetaceans

In-water devices are used in both offshore and inshore areas of the Action Area. Despite thousands of Navy exercises in which in-water devices have been used, there have been no recorded instances of marine species strikes from these devices. The Navy will implement mitigation to avoid potential impacts from in-water device strikes on cetaceans throughout the Action Area. Mitigation includes training Lookouts and watch personnel that have been trained to identify cetaceans and requiring underway vessels and in-water devices that are towed from manned surface platforms to maintain a specified distance from cetaceans (See Section 3.6.2). For these reasons, NMFS considers it extremely unlikely for any ESA-listed cetacean to be struck by an in-water device. It is possible that cetacean species that occur in areas that overlap with in-water device use may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be insignificant to the animal. Therefore, potential effects on ESA-listed cetaceans from in-water devices are extremely unlikely and thus discountable (in the case of strike) or unlikely to be measurable and thus insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects.

Effects of Military Expended Materials on Cetaceans

While no strike of cetaceans from military expended materials has ever been reported or recorded, the possibility of a strike still exists. We considered the potential for ESA-listed cetacean strike resulting from MITT activities involving the following types 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.

Given the large geographic area involved and the relatively low densities of ESA-listed cetaceans in the action area, we do not believe such interactions are likely. Additionally, while disturbance or strike from any expended material as it falls through the water column is possible, it is extremely unlikely because the objects will slow in velocity as they sink toward the bottom (e.g., guidance wires sink at an estimated rate of 0.7 ft [0.2 m] per second; heavier items such as non-explosive munitions would likely sink faster, but would still be slowed as they sink to the bottom), and can be avoided by highly mobile species such as cetaceans. In addition, the Navy has proposed procedural mitigation for vessel movement and towed-in water devices to limit the potential for strikes of cetaceans where military expended materials are used in offshore environments (see Section 3.6.2 for details).

In summary, NMFS considers it extremely unlikely for any ESA-listed cetacean 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 considered minor with no lasting or meaningful effects expected for an individual animal. For these reasons, potential effects on ESA-listed cetaceans from physical disturbance and strike with military expended materials are extremely unlikely and thus discountable (in the case of strikes) or not likely to be measurable and thus insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects.

Effects of Seafloor Devices on Cetaceans

Activities that use seafloor devices include items placed on, dropped on, or moved along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed devices, and bottom-crawling unmanned underwater vehicles. Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. Objects falling through the water column will slow in velocity as they sink toward the bottom and would be avoided by ESA-listed cetaceans. Given their mobility and the low densities in areas where seafloor devices would likely be used, it is extremely unlikely that ESA-listed cetaceans would be struck by a seafloor device. Therefore, potential effects on ESA-listed cetaceans from seafloor device strike are discountable.

Any individuals encountering seafloor devices on the ocean bottom 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 is expected to be minimal and temporary, and will not have fitness consequences. Therefore, the effect of behavioral avoidance of seafloor devices by ESA-listed cetaceans is insignificant, and thus are not likely to cause adverse effects.

Entanglement Stressors – Cetaceans

Expended materials from Navy activities that may pose an entanglement risk include wires, cables, decelerators, and parachutes. Interactions with these materials could occur at the sea surface, in the water column, or on the seafloor. Though there is a potential for ESA-listed cetaceans to encounter military expended material, for the reasons described below, we believe such interactions are extremely unlikely to occur. Additional discussion of entanglement stressors, in general, is included in Section 5.4.

Effects of Entanglement from Wires and Cables on Cetaceans

There has never been a reported or recorded instance of a cetacean entangled in military expended materials despite the Navy expending materials in the action area (and other range complexes) for decades. NOAA (2014a) conducted a review of entanglement of marine species in marine debris with an emphasis on species in the U.S.. The review did not document any known instances where military expended materials 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) conducted a 30-year comprehensive review of entanglement rates of North Atlantic right whales using photographs. Much of the habitat occupied by North Atlantic right whale is coextensive with Navy training and testing activities (i.e., almost identical to activities conducted in the MITT Action Area) using military expended materials in the western Atlantic (Navy 2018a). Knowlton et al. (2012) reported that of the 626 individuals whales observed the vast majority showed evidence of entanglement involving non-mobile pot gear and nets used for fishing. Baulch and Perry (2014) reported that nearly 98 percent of documented cetacean entanglements worldwide were from abandoned, lost, or derelict fishing gear.

If encountered, it is extremely unlikely that an animal would get entangled in a fiber optic cable, sonobuoy wires, or guide wire 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 a design to resist coiling or the forming of loops) the likelihood of cetacean entanglement from cables and wires is extremely low. Specifically, fiber optic cable is brittle and would be expected to break if kinked, twisted or sharply bent. Thus, the physical properties of the fiber optic cable would not allow the cable to loop, greatly reducing the likelihood of entanglement. Based on degradation times, guidance wires would break down within one to two years and no longer pose an entanglement risk.

For these reasons cited above, it is extremely unlikely that ESA-listed cetaceans will become entangled in military expended wires and cables in the action area. The effects from entanglement of ESA-listed cetaceans in wires and cables are, therefore, discountable.

Effects of Entanglement from Decelerators and Parachutes on Cetaceans

The majority of the decelerators and parachutes used for MITT activities are in the small size category and are associated with sonobuoys (i.e., 5,934 out of 5,962 used annually). Both small- and medium-sized decelerators and parachutes are made of cloth and nylon and have weights attached to their short attachment lines (i.e., from 1 to 19 ft). The majority of parachutes/decelerators would not remain suspended in the water column for more than a few minutes as the attached weights speed the sinking of materials to the seafloor. Small and medium decelerators/parachutes with weights are expected to remain at the surface for 5 to 15 seconds before the housing sinks to the seafloor where it becomes flattened (Navy 2019e).

Some large or extra-large decelerators/parachutes are also proposed for use in the action area. In contrast to small and medium parachutes, large parachutes do not have weights attached and may remain at the surface or are suspended in the water column for some time prior to eventual settlement onto the seafloor. However, a limited number of these items are proposed for use (i.e., ten large parachutes annually) in the MITT Action Area. The small number of large or extra-large parachutes proposed for use annually, and generally low species densities, reduces the potential for ESA-listed cetaceans to encounter and become entangled in these items. In addition, during activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. This standard operating procedure could further reduce the potential entanglement of cetaceans in decelerators/parachutes.

As noted above, the vast majority of large whale entanglements have been associated with fishing gear. In contrast, as noted previously, there has never been a documented instance where a large whale was observed entangled in military expended material, including decelerators and parachutes. There are a number of key differences between decelerators/parachutes and fishing gear that result in the likelihood of entanglement in these materials being significantly lower than the likelihood of entanglement in fishing gear. First, as noted above, except for a small number of large decelerators/parachutes, most decelerators/parachutes used by the Navy sink quickly to the seafloor and do not remain suspended in the water column for extended periods of time. This is in contrast to fishing gear which can remain in the water column for days or weeks at a time. Additionally, parachutes would be highly visible in the water column, likely alerting a nearby animal to the presence of the obstacle. By contrast, fishing gear may consist of some buoys and traps that are visible, but often contains hundreds of feet of rope or line in between these items that is often not visible by design. Finally, the cords associated with parachutes are, at most, 80 ft long. In contrast, typical gear associated with some fisheries has hundreds of feet of rope suspended in the water column.

There is the potential for a bottom feeding cetacean (e.g., sperm whale) to become entangled when they are foraging in areas where parachutes have settled onto 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 and being encountered by an ESA-listed cetacean is considered extremely low.

In summary, based on their deep-water location of use, their sinking rate, their degradation rate, and the low density of ESA-listed cetaceans, it is extremely unlikely that these species would become entangled in small or medium decelerators or parachutes. Based on the limited number deployed, the standard operating procedure to recover decelerators/parachutes to the maximum extent practicable, and the low density of ESA-listed cetaceans, and it is extremely unlikely that these species would become entangled in large or extra-large decelerators or parachutes. Therefore, potential effects on ESA-listed cetaceans from entanglement in decelerators or parachutes are discountable.

Ingestion Stressors – Cetaceans

Additional discussion on ingestion stressors is included in Section 5.5. The munitions and other materials small enough to be ingested by ESA-listed cetaceans are small- and medium-caliber projectiles, broken pieces of firing targets, chaff, flare caps, and shrapnel fragments from explosive ordnance. Other military expended materials (e.g., non-explosive bombs or surface targets) are considered too large for ESA-listed cetaceans to consume and are made of metal a cetacean would not be able to break-apart to ingest.

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 cetaceans that do not typically forage on the sea floor. Of the cetaceans 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. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990; Whitehead 2003). However, the relatively low density of both sperm whales and expended materials along the vast sea floor suggests ingestion would be rare. Humpback whales also feed at the seafloor but do so in relatively shallow water and soft sediment areas where ingestion stressors are less likely to be present (fewer activities take place in shallow water and expended materials are more likely to bury in soft sediment and be less accessible). 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 cetaceans may also encounter military expended material that remains suspended in the water column for extended periods of time. Since baleen whales feed by filtering large

amounts of water, they could encounter and consume debris at higher rates than other marine animals (NOAA 2014b). For example, baleen whales are believed to routinely encounter microplastics (from numerous anthropogenic sources) within the marine environment based on concentrations of these items and baleen whale feeding behaviors (Andrady 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 it. 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 training (Arfsten et al. 2002; Force 1997; Hullar et al. 1999). 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 cetaceans 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 Navy activities, where they may persist for long periods, and therefore could be ingested by cetaceans 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 cetaceans. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur.

In conclusion, since ingestion of military expended material of sufficient size to result in adverse effects on ESA-listed cetaceans is extremely unlikely, the effects of this stressor 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, and thus are not likely to cause adverse effects.

Stressors Resulting in Effects to Cetacean Habitat or Prey

This section analyzes potential impacts to ESA-listed cetaceans exposed to stressors through impacts to their habitat or prey or through the introduction of parasites or disease. The stressors evaluated in this section include: 1) explosives 2) explosive byproducts and unexploded munitions, 3) metals, 4) chemicals; and 5) transmission of disease and parasites.

Explosives

Underwater explosions could impact other species in the food web, including prey species that cetaceans feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Hanlon and Messenger 1996; Mather 2004). The abundances of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected. For this reason, the effects of explosives on ESA-listed cetaceans through impacts to their prey are insignificant, and thus are not likely to cause adverse effects.

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 potentially affect cetacean 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 in. 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 cetaceans 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.

Research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016) and an intensively used live fire range in the Mariana Islands (Smith and Marx Jr. 2016) provide

information in regard to the impacts of undetonated materials and unexploded munitions on marine life. Findings from these studies indicate that there were no adverse impacts on the local ecology from the presence of degrading munitions and there was no bioaccumulation of munitions-related chemicals in local marine species.

The island of FDM (in the CNMI) has been used as a target area since 1971. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long term look at potential impacts on the marine life from training and testing involving the use of munitions (Smith and Marx Jr. 2016). Munitions use has included high-explosive rounds from gunfire, high-explosives bombs by Navy aircraft and U.S. Air Force B-52s, in addition to the expenditure of inert rounds and non-explosive practice bombs. Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, and bony fishes, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the biological resources had been adversely impacted to a significant degree by the Navy training activities (Smith and Marx Jr. 2016). Furthermore, they found that the health, abundance, and biomass of fishes, corals and other marine resources were comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago.

The concentration of munitions, explosives, expended material, or devices in any one location in the action area are expected to be a small fraction of that from the sites described above. As a result, explosion by-products and unexploded munitions are not anticipated to have adverse effects on water quality or cetacean prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on ESA-listed cetaceans through impacts on prey and water quality are considered insignificant, and thus are not likely to cause adverse effects.

Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, munitions, and other military expended materials (Environmental Sciences Group, 2005). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Evidence from a number of studies (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013c) indicate metal contamination is 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 since 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 cetacean prey. The research cited above indicates that metals introduced into the Action Area are unlikely to have adverse effects on ESA-listed cetacean prey or habitat. Thus, the effects of metals introduced into seawater and sediments as a

result of MITT activities on ESA-listed cetaceans through impacts to their prey or habitat are insignificant, and thus are not likely to cause adverse effects.

Chemicals

Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed cetaceans 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 bioconcentrate 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 cetacean prey or habitat. In summary, the effects of chemicals used during Navy training and testing on ESA-listed cetaceans via water quality and prey are considered discountable.

8.1.2 Sea Turtles

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed green, hawksbill, leatherback, and loggerhead sea turtles (note: olive ridley were determined to be not likely adversely affected by any stressors in Section 6.1.1 above). As noted above, our analysis for these stressors is organized on the taxa level (i.e., sea turtles) because the pathways for effects for these stressors is generally the same for all sea turtles and we would not expect different effects at the species level. While there is variation among species within each taxa, the sea turtle species considered in this opinion share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action. Our analysis for these stressors and sea turtles is summarized below.

Acoustic Stressors – Sea Turtles

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. In the following section we discuss the acoustic stressors we determined are not likely to adversely affect ESA-listed sea turtles. Additional discussion of the acoustic stressors associated with the proposed action is included in Section 5.1 above. The effects of acoustic stressors which we determined are likely to adversely affect sea turtles are discussed in Section 8.2.2.

Effects of Vessel Noise on Sea Turtles

ESA-listed turtles could be exposed to a range of vessel noises within their hearing abilities. The Navy vessels used during training and testing activities will produce low-frequency, broadband underwater sound below one kHz for larger vessels, and higher-frequency sound between one kHz to 50 kHz for smaller vessels, although the exact level of sound produced varies by vessel type. Depending on the context of exposure, potential responses of the ESA-listed sea turtle species in the action area to vessel noise disturbance would likely include startle responses, avoidance, or other behavioral reactions, and physiological stress responses.

Limited information is available on how or if ESA-listed sea turtles may respond to noise from Navy vessels during MITT training and testing activities. As discussed previously, Hazel et al. (2007) suggested that green turtles rely more on visual than auditory cues when reacting to approaching vessels. Additionally, there is evidence that reptiles 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). This suggests that if sea turtles were to respond to a Navy vessel, the animal might not respond to the vessel based on noise alone. Popper et al. (2014) stated that no data are available on the potential effect of vessel noise or other continuous sounds on sea turtles. The only potential effect Popper et al. (2014) suggested could occur from vessel noise was behavioral response or masking, with a higher likelihood of a behavioral response occurring the closer the sea turtle is to the vessel.

Compared to marine mammals that are highly adapted to use sound in the marine environment, sea turtles are less dependent on sound and their hearing is more limited in range to very low frequencies. Any masking of biologically important sounds for sea turtles would be temporary, occurring only when a vessel and sea turtle are in close proximity to one another, as such we do not expect such an incident to have any measurable effects on an animal's fitness.

If a sea turtle responded behaviorally to noise from a Navy vessel, most responses would consist of slow movements away from vessels the animals perceive are on an approaching course, perhaps accompanied by slightly longer dives. Changes in behavior would likely consist of a temporary shift from behavioral states that have low energy requirements (resting or milling) to behavioral states with higher energy requirements (active swimming or traveling) and then returning to the resting or milling behavior shortly thereafter. Any behavioral responses to vessel noise are expected to be temporary (e.g., a startle response, brief avoidance behavior) and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to baseline behavior immediately following exposure to the vessel noise. We do not expect these short term behavioral reactions to increase the likelihood of injury or result in fitness consequences to exposed individuals.

For these reasons, vessel noise is expected to cause minimal disturbance to sea turtles. If a sea turtle detects a vessel and avoids it, or has a temporary stress response from the noise

disturbance, these responses are expected to be temporary and only endured while the vessel transits through the area where the sea turtle encountered it. Sea turtle responses to vessel noise disturbance would amount to minor, temporary behavioral responses, as a sea turtle would be expected to return to normal behaviors and baseline stress levels shortly after the vessel passes. In summary, we find that the likely effects from exposure to vessel noise are insignificant, and thus are not likely to cause adverse effects, for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian–West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Effects of Aircraft Noise on Sea Turtles

Based on sea turtle sensory biology (Ketten and Bartol 2006; Lenhardt et al. 1994; Ridgway et al. 1969), sound from low flying aircraft could be heard by a sea turtle at or near the surface. Turtles might also detect low flying aircraft via visual cues such as the aircraft's shadow. This suggests that sea turtles might not respond to aircraft overflights based on noise alone.

Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead at relatively high speeds. Exposure to helicopter overflights may last longer and would have a higher likelihood of causing a behavioral response from a sea turtle due to the lower flight altitudes and longer duration the helicopter could be in proximity to an animal. The Navy proposes to conduct exercises involving helicopters both during the day and night. These exercises may occur for extended periods of time, up to a couple of hours in some areas. During these activities, helicopters would typically transit throughout an area and may hover over the water. Longer duration activities (such as a couple of hours) and periods of time where helicopters hover may increase the chance that a sea turtle may startle, change swimming patterns, or have a physiological stress response. Exposures to both sorts of aircraft would be infrequent based on the transitory and dispersed nature of the overflights and repeated exposure to individual animals over a short period of time (hours or days) is extremely unlikely. Furthermore, the SEL would be relatively low to sea turtles that spend the majority of their time underwater and may not even detect the aircraft depending on where they are at in the water column at the time of the overflight.

As with vessel disturbance above, little information is available on how ESA-listed sea turtles respond to aircraft. The working group that developed the 2014 ANSI Guidelines for fish and sea turtles (Popper et al. 2014) did not consider this specific acoustic stressor for sea turtles, in part because it is not considered to pose a great risk. For the purposes of this consultation, we assume all ESA-listed sea turtles in the action area may exhibit similar short-term behavioral responses (e.g., diving, changes in swimming direction, etc.) consistent with those behaviors observed during aerial research surveys of sea turtles. We are unaware of any data on the physiological responses sea turtles exhibit to aircraft, but we conservatively assume a low-level, short-term stress response is possible. 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 considered very 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, the brief responses expected to the noise or visual disturbance produced and the inconsequential nature of the behavioral response, the effects of aircraft overflight noise on ESA-listed sea turtles are considered temporary and minor. In summary, we find that the likely effects from exposure to aircraft overflight noise are insignificant, and thus are not likely to cause adverse effects, for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Effects of Weapons Firing, Launch, and Impact Noise on Sea Turtles

Individual sea turtles from all of the ESA-listed species may be exposed to sounds caused by weapons firing (guns, missile, torpedoes), objects dropping in the water, and inert impact of non-explosive munitions on the water's surface. In general, these are impulsive sounds generated in close proximity to or at the water surface (with the exception of items that are launched underwater). Most in-air weapons noise is expected to be reflected at the air-water interface, and as such is not expected to transmit deep into the water column, nor to propagate across a large expanse of surface waters. The resulting noise would be limited and strongest underwater just below the surface and directly under the firing point of the weapon. Sound produced from missile and target launches is typically the highest near the initiation of the booster rocket and rapidly fades as the missile or target travels downrange from the firing point (Navy 2018b).

The highest level of sound expected to transmit to the water would be from large-caliber guns fired at the lowest elevation angle with peak levels of sound directly below the blast. These peak levels are approximately 200 dB (re 1 μPa). These levels are lower than the impulsive sound pressure thresholds that are thought capable of causing hearing impairment or injury to sea turtles, but higher than the rms value (175 dB) that could elicit a behavioral response. Therefore, the potential effects that are more likely to result from weapons noise exposure for sea turtles are temporary behavioral responses, masking and concurrent stress responses.

Noise produced from firing weapons is expected to last only 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 (Navy 2018b). Gunfire activities could produce multiple shots fired in a brief period of time. Given that these sounds are below injury criteria for sea turtles, and are expected to be very brief and intermittent over the duration of activities in the action area, only brief startle reactions, diving responses or other avoidance behaviors are likely

to occur for sea turtles. For the same reasons, masking of biologically relevant sounds is also not expected to occur for sea turtles because weapons noise would not persist for a long enough duration, and sea turtles are more likely to rely on other senses to detect environmental cues such as visually or through orientation to the earth's magnetic field. Most weapons firing activities would typically occur in offshore areas where sea turtles densities are lowest. As such, sea turtle foraging behavior in nearshore portions of the Action Area or reproductive behavior near nesting beaches would not likely be affected by weapons firing activities.

For the reasons above, 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 measurable disruption of important behavioral patterns. Sea turtle behavioral and stress responses to weapons noise are anticipated and a sea turtle would be expected to return to normal behaviors and baseline stress levels shortly after the weapon is fired. In summary, we find that the likely effects from exposure to weapons noise are insignificant, and thus are not likely to cause adverse effects, for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Effects of Explosions in Air on Sea Turtles

Explosions that occur during air warfare would typically be at sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude and would not reach the water's surface where ESA-listed species could occur. Sea turtles within the audible range of sound from explosions in air may exhibit a behavioral startle response but are expected to quickly return to normal behavior. Due to the short duration and sporadic nature of explosions in the air and the extremely low likelihood of an ESA-listed sea turtle being within close enough proximity to detect sounds from such explosions, we do not expect this stressor would result in a measurable disruption of important behavioral patterns, including, breeding, feeding, or sheltering or result in reduced fitness of exposed individuals. Therefore, the effects of sound from explosions in air on ESA-listed sea turtles would be insignificant, and thus are not likely to cause adverse effects.

Effects of Sonars and Other Transducers on Sea Turtles

The potential effects of sea turtle sonar exposure include hearing impairment, an observable behavioral response, a stress response that may not be detectable, or masking. These potential effects are discussed below, with reference to Section 2.2 as appropriate, which describes the criteria and thresholds for estimating potential effects from sonar.

Hearing Impairment

Hearing loss is a noise-induced decrease in hearing sensitivity, which can either be temporary or permanent. To date, no studies have been conducted specifically related to sea turtle hearing loss. The Navy evaluated sea turtle susceptibility to hearing loss (from sonar exposure) based upon what is known about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species such as marine mammals and fish. The criteria and thresholds used to evaluate the potential for hearing impairment in sea turtles from Navy sonar is described in Section 2.2.5.

Physiological stress

Stress caused by acoustic exposure has not been studied for sea turtles. As described for cetaceans, a stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long it can have negative consequences to the animal such as low reproductive rates, decreased immune function, diminished foraging capacity, etc. Physiological stress is typically analyzed by measuring stress hormones (such as cortisol), other biochemical markers, and vital signs. To our knowledge, there is no direct evidence indicating that sea turtles will experience a stress response if exposed to acoustics stressors. However, physiological stress has been measured for sea turtles during nesting, capture and handling (Flower et al. 2015; Gregory and Schmid 2001; Jessop et al. 2003; Lance et al. 2004), and when caught in entanglement nets and trawls (Hoopes et al. 2000; Snoddy et al. 2009). Therefore, based on their response to these other anthropogenic stressors, and including what is known about cetacean stress responses, we assume that some sea turtles will experience a stress response if exposed to a detectable sound stressor. Compared to other marine animals, such as marine mammals which are highly adapted to use sound in the marine environment, sea turtle hearing is limited to lower frequencies and is less sensitive. As such, the range of sounds that may produce a stress response in sea turtles is expected to be more limited compared with other taxa that are more sensitive to acoustic stressors.

Animals often respond to anthropogenic stressors in a manner that resembles a predator response (Beale and Monaghan 2004; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). As predators generally induce a stress response in their prey (Dwyer 2004; Lopez and Martin 2001; Mateo 2007), we assume that sea turtles may experience a stress response if exposed to acoustic stressors, especially loud sounds. We expect breeding adult females may experience a lower stress response, as studies on loggerhead, hawksbill, and green turtles have demonstrated that females appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al.

2004). However, anthropogenic sound producing activities may have the potential to provide additional stressors beyond those that naturally occur.

Due to the limited information about acoustically induced stress responses in sea turtles, we assume physiological stress responses would occur concurrently with any other response such as hearing impairment or behavioral disruptions. However, we expect such responses to be brief, with animals returning to a baseline state within hours to days. As with cetaceans, such a short, low level stress response may in fact be adaptive and beneficial as it may result in sea turtles exhibiting avoidance behavior, thereby minimizing their exposure duration and risk from more deleterious, high sound levels.

Masking

Masking, as described in Section 8.1.1 above, can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options. Compared to other marine animals, such as marine mammals which are highly adapted to use sound in the marine environment, sea turtle hearing is limited to lower frequencies and is less sensitive. Because sea turtles likely use their hearing to detect broadband low-frequency sounds in their environment, the potential for masking would be limited to certain sound exposures. Only continuous anthropogenic sounds that have a significant low-frequency component, are not of brief duration, and are of sufficient received level could create a meaningful masking situation (e.g., long-duration vessel noise affecting natural background and ambient sounds). Other intermittent, short-duration sound sources with low-frequency components (e.g., low-frequency sonar) would have more limited potential for masking, depending on how frequently the sound occurs.

As described previously, there is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013), magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015), and scent (Shine et al. 2004). Thus, any effect of masking on sea turtles could be mediated by their normal reliance on other environmental cues.

Behavioral Responses

Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. The response of a sea turtle to an anthropogenic sound would likely depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered. In the ANSI Guidelines (Popper et al. 2014), qualitative risk factors were developed to assess the potential for sea turtles to respond to various underwater sound sources.

To date, very little research has been conducted on sea turtle behavioral responses relative to sonar exposure. Because of this, the working group that prepared the ANSI Guidelines provide

parametric descriptors of sea turtle behavioral responses to sonar and other transducers. The working group estimate that the risk of a sea turtle responding to a low-frequency sonar (less than one kHz) is low regardless of proximity to the source, and that there is no risk of a sea turtle responding to a mid-frequency sonar (one to ten kHz).

For purposes of our effects analysis, we requested the Navy estimate the number of sea turtles that could be exposed to sonar within their hearing range at received levels of 175 dB rms re: 1 μPa SPL or greater. This level is based upon work by McCauley et al. (2000b), who experimentally examined behavioral responses of sea turtles in response to seismic air guns. The authors found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB rms (re: 1 μPa), or slightly less, in a shallow canal. They reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB rms (re: 1 μPa). At 175 dB rms (re: 1 μPa), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000b). Based on these data, NMFS assumes that sea turtles would exhibit a significant behavioral response in a manner that constitutes harassment or other adverse behavioral effects, when exposed to received levels of 175 dB rms (re: 1 μPa). This is the level at which sea turtles are expected to begin to exhibit avoidance behavior based on experimental observations of sea turtles exposed to multiple firings of nearby or approaching air guns. Because data on sea turtle behavioral responses to non-impulsive sounds, such as sonars, is limited, the air gun dataset was used to inform potential risk. We considered that the relative risk of a sea turtle responding to air guns would be higher than the risk of responding to sonar, so it is likely that potential sea turtle behavioral responses to sonar exposures are a sub-set of sea turtles exposed to received levels of 175 dB rms (re: 1 μPa) or greater.

Exposure and Response Analysis

The Navy's quantitative analysis (discussed above in Section 2.2) predicts that no sea turtles of any species are likely to be exposed to the high received levels of sound from sonars or other transducers that could cause PTS or TTS during a maximum year of training and testing activities under the proposed action. Only a limited number of sonar and other transducers with frequencies within the range of sea turtles' hearing (less than two kHz) and high source levels have the potential to cause TTS and PTS. The quantitative analysis, also predicts no sea turtles of any species are likely to be exposed to received levels from sonars in their hearing range at or exceeding 175 dB re 1 μPa SPL (rms), the received level associated with onset of avoidance behavior in air gun studies. Therefore, no sea turtles are expected to exhibit avoidance or any other higher severity behavioral response to sonars or other transducers during a maximum year of training and testing activities. Although masking of biologically relevant sounds by the limited number of sonars and other transducers operated in sea turtle hearing range is possible, this may only occur in certain circumstances. Sea turtles most likely use hearing to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach. The use characteristics of most sonars, including limited bandwidth, beam directionality, limited beam width, relatively low source levels, low duty cycle, and limited duration of use,

would both greatly limit the potential for a sea turtle to detect these sources and limit the potential for masking of broadband, continuous environmental sounds. In addition, broadband sources within sea turtle hearing range, such as countermeasures used during anti-submarine warfare, would typically be used in offshore areas, not in nearshore areas where detection of beaches or concentrated vessel traffic is relevant. Implementation of mitigation may further reduce the already low risk of auditory impacts on sea turtles. Depending on the sonar source, mitigation includes powering down the sonar or ceasing active sonar transmission if a sea turtle is observed in the mitigation zone, as discussed in Section 3.6.2 (Mitigation Measures).

Due to the short term and infrequent nature of any exposures to sonar and transducers and the brief responses that could follow such exposure, the effects of sonar and transducers on ESA-listed sea turtles is considered temporary and minor. Intensity and duration of effects will be at a level not causing harassment or injury or with the potential to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. In summary, we find that the likely effects from exposure to sonar and transducers are insignificant, and thus are not likely to cause adverse effects, for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Effects of Other Acoustic Sources Not Quantitatively Analyzed

Several of the acoustic sources associated with MITT activities were not quantitatively analyzed in terms of their effects on ESA-listed species These include the following: broadband sound sources; Doppler sonar; fathometers; hand-held sonar; imaging sonar; high-frequency acoustic modems; tracking pingers; acoustic releases; and side-scan sonars (see Table 22 above for details). When used during routine training and testing activities, and in a typical environment, these sources fall into one or more of the following categories:

- Transmit primarily above 200 kHz: Sources above 200 kHz are above the hearing range of the ESA-listed species in the action area.
- Source levels of 160 dB re 1 μPa or less: Low-powered sources with source levels less than 160 dB re 1 μPa are typically hand-held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB re 1 μPa source, the sound will attenuate to less than 140 dB re 1 μPa within ten meters (m) and less than 120 dB re 1 μPa within 100 m of the source. Ranges would be even shorter for a source less than 160 dB re 1 μPa source level. As discussed above (Section 2.2.2) we assume that sea turtles would not exhibit a behavioral response when exposed to such low source levels.
- Acoustic source classes listed in Table 22: Sources with operational characteristics, such as short pulse length, narrow beam width, downward-directed beam, and low energy release, or manner of system operation, which exclude the possibility of any significant impact on an ESA-listed species (actual source parameters are classified). Even if there is a possibility that some species may be exposed to and detect some of these sources, any

response is expected to be short term and insignificant, and thus are not likely to cause adverse effects.

Therefore, these acoustic sources associated with MITT activities (as described in Table 22) would either have no effect on ESA-listed sea turtles, or the effects would be insignificant (and thus are not likely to cause adverse effects), depending on the particular source considered.

Effects of Explosive Sources Not Quantitatively Analyzed

In addition to the explosives quantitatively analyzed for impacts to ESA-listed species (shown in Table 23 above), the Navy uses some very small impulsive sources (less than 0.1 lb. NEW), categorized in bin E0, that were not quantitatively analyzed by the Navy for potential exposure to ESA-listed species. Quantitative modeling in multiple locations has indicated that these sources have a very small zone of influence. As such, it is extremely unlikely that ESA-listed sea turtles would be exposed to explosives in bin E0. Therefore, potential effects from explosives in bin E0 on ESA-listed sea turtles are discountable.

Energy Stressors – Sea Turtles

This section analyzes the effects of energy stressors used during training and testing activities on sea turtles within the action area. Additional discussion on energy stressors is included in Section 5.2. This section includes analysis of the potential impacts of: 1) in-water electromagnetic devices and 2) high-energy lasers.

Effects of In-water Electromagnetic Devices on 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 species (Christiansen et al. 2016b). This biological trait enables sea turtles to locate seasonal feeding and breeding grounds and return to their nesting sites (Lohmann and Lohmann 1996; Lohmann and Lohmann 1998). Sea turtles also have the ability to detect changes in magnetic fields, which may cause them to deviate from their original direction. 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 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.

The in-water electromagnetic devices that the Navy proposes to use during training and testing activities include towed or unmanned mine warfare systems that mimic the electromagnetic signature of a vessel passing through the water. In general, the voltage used to power these devices is approximately 30 volts, with just 35 volts (capped at 55 volts) in saltwater, required to generate a current. These levels are considered safe for marine species due to the low charge relative to salt water. The static magnetic field generated by the mine neutralization devices is of relatively minute strength. The maximum strength of the magnetic field is approximately 2,300 microteslas (μT), with the strength of the field decreasing further from the device (Navy 2018b). At a distance of four meters from the source of a 2,300 μT magnetic field, the strength of the field is approximately 50 μT, which is within the range of the Earth's magnetic field (25 to 65 μT). At eight meters from a 2,300 μT magnetic field the strength of the field is approximately 40 percent of the Earth's magnetic field, and at 24 m away only ten percent (Navy 2018b). 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 2018b), which is less than one percent of the strength of the Earth's magnetic field. This is likely within the range of detection for sea turtle species, but at the lower end of their sensitivity to the field.

For any sea turtles located in the immediate area (within about 200 m) where in-water electromagnetic devices are being used, adult, sub-adult, juvenile, and hatchling sea turtles could be temporarily disoriented and could deviate from their original movements. However, 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 effect, beyond what would be similar to natural stressors regularly occurring in the animal's life cycle. We considers it extremely unlikely that a sea turtle would be exposed to electromagnetic energy at sufficient intensities to create an adverse effect through behavioral disruption or otherwise. In summary, we find that the likely effects from exposure to in-water electromagnetic devices are discountable for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Effects of Lasers on Sea Turtles

As discussed above, high-energy laser (lasers) weapons training and testing involves the use of up to 30 kilowatts of directed energy as a weapon against small surface vessels and airborne targets. These weapons systems are deployed from surface ships and helicopters to create small

but critical failures in potential targets and used at short ranges from the target (Navy 2018b). Lasers would only be used in open ocean areas of the Action Area, and would therefore not affect nearshore area where sea turtle densities are highest.

The primary concern with lasers used during Navy training and testing is the potential for a sea turtle to be struck by a high-energy laser beam. Traumatic burns from the high-energy beam could result in injury or death of a sea turtle. Sea turtles could only be exposed to the beam if the laser missed the target and inadvertently hit a sea turtle was located near the target. If this were to occur it would likely be for turtles located at or near the surface. Laser platforms are typically on helicopters and ships, which may cause sea turtles to move away from the area for reasons such as ship or aircraft noise, making a strike from the laser beam less likely.

The potential for sea turtles to be directly hit by a high-energy laser beam was evaluated by the Navy using statistical probability modeling to estimate the potential direct strike exposures to a sea turtle for a worst-case scenario. Model input values include high-energy laser use data (e.g., number of high-energy laser exercises and laser beam footprint), size of the training or testing area, sea turtle density data, and animal footprint. To estimate the probability of hitting a sea turtle in a worst-case scenario (based on assumptions listed below), the impact area for all laser training and testing events was summed over one year. Finally, the sea turtle species with the highest average seasonal density (i.e., green sea turtles) within the training or testing area was used in the analysis. All other species with a lower density would be expected to have a lower probability of being struck by a laser. Other conservative assumptions incorporated into the model are as follows:

- The model is two-dimensional and assumes that all animals would be at or near the surface 100 percent of the time.
- The model assumes the animal is stationary and does not account for any movement of the sea turtles or any potential avoidance of the training or testing activity.

The Navy's model estimates 0.000027 annual exposures of each sea turtles species (or DPS). Based on the very low number of annual exposures, the characteristics of activities that would use high-energy lasers (e.g., short range distance from source to target, high-precision targeting, short duration of the energized beam), and likely avoidance behavior of stressors, NMFS considers it extremely unlikely that ESA-listed sea turtles would be exposed to high energy lasers. Therefore, potential effects from lasers on ESA-listed sea turtles are discountable.

Physical Disturbance and Strike Stressors – Sea Turtles

Additional discussion on physical disturbance and strike stressors is included in Section 5.3. This section analyzes the potential impacts of the various types of physical disturbance, including the potential for strike, during training and testing activities within the action area from in-water devices, military expended materials (including non-explosive practice munitions and fragments

from high-explosive munitions), and seafloor devices. The potential for vessel strike of sea turtles is discussed below in Section 8.2.2.

Effects of In-water Devices on Sea Turtles

Despite thousands of Navy exercises in which in-water devices have been used, there have been no recorded instances of marine species strikes from these devices. The Navy will implement mitigation to avoid potential impacts from in-water device strikes on sea turtles throughout the Action Area. Mitigation includes training Lookouts and watch personnel to identify sea turtles and requiring underway vessels and in-water devices that are towed from manned surface platforms to maintain a specified distance from sea turtles (See Section 3.6.2). For these reasons, NMFS considers it extremely unlikely for any ESA-listed sea turtle to be struck by an in-water device. It is possible that sea turtles that occur in areas that overlap with in-water device use may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be minor and temporary for the animal. Therefore, potential effects on ESA-listed sea turtles from in-water devices are discountable (in the case of strikes) or insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects.

Effects of Military Expended Materials on Sea Turtles

While no strike of sea turtles from military expended materials has ever been reported or recorded, the possibility of a strike still exists. We considered the potential for ESA-listed sea turtle strike resulting from MITT activities involving the following types 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.

Navy activities involving military expended materials occur both nearshore and offshore within the MITT Action Area, but the majority of materials would be expended in offshore areas (Navy 2018b) where sea turtle densities are very low. For training activities occurring in the offshore waters, the species and age classes most likely to be impacted are hatchlings and pre-recruitment juveniles of all sea turtle species, adult loggerhead turtles, and leatherback turtles of all age classes. Adult sea turtles in these areas could be located at the surface of the water, but generally spend most of their time submerged. Thus, adult sea turtles are expected to be at the surface for brief periods of time compared to hatchlings and juveniles; as these early life stages spend more time at the surface while in ocean currents. However, all life stages do spend some time at the surface basking. Moreover, sea turtles are expected to be widely distributed in offshore waters, decreasing the chances of a single or repeated exposure to sea turtles since these offshore areas do not have sea turtle presence year-round. In addition, the Navy has proposed procedural mitigation for vessel movement and towed-in water devices to limit the potential for strikes of

sea turtles where military expended materials are used in offshore environments (see Section 3.6.2 for details).

Additionally, while disturbance or strike from any expended material as it falls through the water column is possible, it is extremely unlikely because the objects will slow in velocity as they sink toward the bottom (e.g., guidance wires sink at an estimated rate of 0.7 ft [0.2 m] per second; heavier items such as non-explosive munitions would likely sink faster, but would still be slowed as they sink to the bottom), and can be avoided by highly mobile species such as sea turtles. In addition, the Navy has proposed procedural mitigation for vessel movement and towed-in water devices to limit the potential for strikes of cetaceans where military expended materials are used in offshore environments (see Section 3.6.2 for details).

In summary, NMFS considers it extremely unlikely for any ESA-listed sea turtle 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 likely inconsequential to an individual sea turtle. For these reasons, we find the potential effects from physical disturbance and strike with military expended materials are discountable (in the case of strikes) or insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects, for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Effects of Seafloor Devices on Sea Turtles

The types of activities that use seafloor devices include items placed on the seafloor, dropped on the seafloor, or that move along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed instruments, and bottom-crawling unmanned underwater vehicles (Navy 2018b). The likelihood of any sea turtle species encountering seafloor devices is considered low because these items are either stationary or move very slowly along the bottom. Sea turtles would be expected to ignore or avoid any slowly moving or stationary device. Based on the Navy model that estimated the number of sea turtles present when military materials are expended (described above), which also takes into account the use of seafloor devices, the probability of an individual sea turtle being struck by a seafloor device is extremely low (Navy 2018b). Considering the extremely low probability of occurrence, NMFS considers it extremely unlikely for any sea turtles to be exposed to seafloor devices as part of the proposed action. Therefore, potential effects on sea turtles from seafloor devices are considered discountable. In summary, we find that the probability of exposure to effects of seafloor devices is discountable for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Entanglement Stressors – Sea Turtles

All of the ESA-listed sea turtles present within the action area could encounter materials that may entangle them such as wires, cables, decelerators and parachutes that are used during Navy activities. Sea turtles could encounter these items at the water's surface, in the water column, or along the seafloor. Many factors influence the degree of entanglement risk for sea turtles such as and life stage and size, sensory capabilities, and foraging methods (i.e. along the seafloor or in the water column). Similar to other marine animals, most entanglements associated with sea turtles are from fishing gear that float or are suspended at the ocean's surface for long periods of time.

Effects of Entanglement in Cables and Wires on Sea Turtles

Expended fiber optic cables, which range in size up to 3,000 m in length, can pose a potential entanglement risk for sea turtles. However, because expended fiber optic cables sink rapidly are not expected to remain suspended in the water column for long periods the likelihood of a turtle at the surface or in the water column encountering them is low. In addition, the material from these cables is very brittle and breaks easily if bent or twisted, which also decreases the likelihood that a turtle would become ensnared. Furthermore, most of the Navy activities that use fiber optic cables occur in deeper waters where sea turtle densities are relatively low. Most cables would ultimately settle in deep ocean substrates beyond the diving depth range for the sea turtle species and life stages considered here (Navy 2018b). In addition to expended fiber optic cables, the Navy proposes to temporarily deploy slightly negatively buoyant fiber optic cables at depths of approximately 600 to 850 ft up to approximately 60 mi in length. Since these longer cables would be recovered immediately following their use there is very little risk of sea turtle entanglement.

Similar to fiber optic cables, guidance wires may pose an entanglement threat to sea turtles either in the water column or after the wire has settled to the seafloor. However, the likelihood of a sea turtle encountering and becoming entangled in a guidance wire is low. The sink rate to the seafloor (at an estimated rate of 0.7 ft per second) is fast, and the probability of a sea turtle encountering a wire as it descends is lower than encountering it after it has settled. Also similar to fiber optic cables, guide wires have a relatively low tensile breaking strength (between 10 and 42 lb) which further reduces the entanglement risk for sea turtles. Guidance wires may also degrade after settling along the substrate. The Navy estimates they would break down within one to two years and therefore no longer pose an entanglement risk after that time (Navy 2018b).

Sonobuoy wires, consist of a thin-gauge, hard draw copper strand wire, wrapped by a hollow rubber tubing or bungee. The tensile breaking strength of the sonobuoy wire and rubber tubing is no more than 40 lb. Operationally, sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor, which would increase the likelihood that a sea turtle could encounter a sonobuoy wire either while it is suspended or as it sinks (Navy 2017). However, as with fiber optic wires, sonobuoys are weak and likely to break if wrapped

around a sea turtle. Bathythermograph wires are similar to sonobuoys, and expected to have the same fate, as such are expected to pose little risk for sea turtles.

Any ESA-listed sea turtles that occurs within the action area could at some time encounter expended cables or wires. Based upon the geographic locations where the Navy would likely use these materials (i.e., deep water areas), they pose a higher risk of entanglement for sea turtles located at the surface or in the water column rather than those foraging along the seafloor. Because of this, hatchlings and pre-recruitment juveniles of all sea turtle species, and leatherback turtles of all age classes are more likely to encounter these materials in offshore areas. Due to their size, adult sea turtles may have a higher risk of entanglement than smaller turtles such as hatchlings and juveniles, since larger turtles are considered less able to disentangle from loops that may form in lines. However, since this material has different tensile strength and breaks easier than fishing gear (which is more commonly the cause of sea turtle entanglement), the risk of a larger seas turtle remaining entangled in wires or cables is low.

In shallow, nearshore waters, wires and cables may pose a slight risk to juvenile, sub-adult, and adult green and hawksbill turtles that forage along the substrate. However, most cables from sonobuoys would be expended in waters too deep for benthic foraging, so bottom foraging sea turtles would not interact with them once they sink, thereby decreasing any risk of entanglement for these species and life stages. Moreover, the sink rates of cables and wires would minimize the potential for these items to drift into nearshore and coastal areas from offshore, where these species and life stages are more likely to occur in benthic foraging areas.

Given the low concentration of expended wires and cables, the rapid sink rates, and likely distribution of sea turtles in the action area that may be concurrent where cables and wires are expended, the likelihood of a sea turtle encountering a wire or cable and becoming entangled is extremely low. Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for any sea turtles to be exposed to entanglement in cables and wires as part of the proposed action. Therefore, potential effects from entanglement in cables and wires are considered discountable for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Effects of Entanglement in Decelerators and Parachutes on Sea Turtles

The majority of the decelerators and parachutes used for MITT activities are in the small size category and are associated with sonobuoys (i.e., 5,934 out of 5,962 used annually). Both small- and medium-sized decelerators and parachutes are made of cloth and nylon and have weights attached to their short attachment lines (i.e., from 1 to 19 ft) to speed their sinking. The majority of parachutes/decelerators would not remain suspended in the water column for more than a few minutes, as most have weights that speed the sinking of the materials to the seafloor. Small and medium decelerators/parachutes with weights are expected to remain at the surface for 5 to 15 seconds before the housing sinks to the seafloor where it becomes flattened (Navy 2019e).

Some large or extra-large decelerators/parachutes are also proposed for use in the action area. In contrast to small and medium parachutes, large parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to eventual settlement on the seafloor. However, a limited number of these items are proposed for use (i.e., ten large parachutes annually) in the MITT Action Area. The small number of large or extra-large parachutes proposed for use annually, and generally low species densities, reduces the potential for ESA-listed sea turtles to encounter and become entangled in these items. During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. This standard operating procedure could further reduce the potential entanglement of cetaceans in decelerators/parachutes.

Leatherbacks are more likely to co-occur where decelerators and parachutes would be deployed given this species' preference for offshore, open-ocean habitats. Since leatherback are known to forage on jellyfish at or near the surface, exposure would involve either the decelerator or parachute landing directly on the turtle or the turtle swimming into it before it sinks. The likelihood of this occurring is very low. Overall, given the low probability of a sea turtle being near a deployed decelerator or parachute, as well as the general behavior of sea turtles, we find the likelihood of entanglement to be extremely low. Therefore, the potential effects from entanglement in decelerators and parachutes are considered extremely unlikely and thus discountable for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Ingestion Stressors – Sea Turtles

The munitions and other materials NMFS considers small enough to be ingested by ESA-listed sea turtles are small and medium caliber projectiles (up to 2.25 in), broken pieces of firing targets, chaff, flare casings (caps and pistons), decelerators and parachutes (cloth, nylon and metal weights) and shrapnel fragments from high-explosives ordnance (Navy 2018b). 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 2018b). In inshore waters, training activities would concentrate small-caliber shell casings in areas that may potentially be over benthic foraging areas. Sea turtles potentially affected in these areas would be juvenile, sub-adult, and adult green sea turtles and juvenile 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 that sink to the bottom.

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, such as metal materials. Other munitions and munitions fragments such as large-caliber projectiles or intact training and testing bombs are too large for sea turtles to consume. Since they are made of metal a sea turtle would not be able to break it apart and ingest it (Navy 2018b).

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 chaff 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 (Navy 2018b). Chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to their light weight and small size, chaff float and can be carried great distances in both air and water currents (Navy 2018b). 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 (Navy 2018b).

Chaff cartridge plastic end caps and pistons and flare pads and pistons would also be released into the marine environment during Navy activities. These materials may persist in the environment for long periods, and therefore could be ingested by sea turtles while initially floating on the surface or sinking through the water column (Navy 2018b). These materials would eventually sink to the seafloor where they would be less likely to be ingested by sea turtles that forage at or near the surface (i.e., hatchlings and pre-recruitment juveniles of all sea turtle species and all life stages of leatherbacks). Green and hawksbill sea turtles could be at an increased risk of ingesting cartridges, plastic end caps, pistons and pads that settle in potential benthic feeding habitat.

Should a sea turtle encounter military expended materials, it is unlikely that it would ingest every fragment. Sea turtles may attempt to ingest a projectile and then reject it, after realizing it is not a food item. It is likely that most ingested material would pass through the digestive tract of the animal. NMFS is also unaware of any data indicating these items have been found in sea turtles that have been necropsied, unlike plastics that appear similar to jellyfish or other turtle prey and are found in a large proportion of sea turtles worldwide (Schuyler et al. 2016). Therefore, negative impacts of fragment ingestion may be limited to the unlikely event of an item that becomes embedded in tissue or is too large to be passed through the digestive system. The likelihood of this occurring would be low. The chances of a sea turtle ingesting expended materials in the water column increase if it is within close proximity to falling munitions, mistakes a sinking munition for prey, and reacts quickly enough to ingest the sinking material.

If a sea turtle were to ingest any of the military expended materials discussed above, short-term or long-term effects could occur such as disruption in feeding behavior or digestive processes. If

the material or fragment is particularly large in proportion to the turtle ingesting it, the item could become permanently encapsulated in the stomach lining and, although rare, could impede the turtle's ability to feed or take in nutrients. Therefore, a sea turtle could have reduced growth, survival, or reproductive success. However, munitions used in training and testing activities are generally not expected to cause such reactions in sea turtles. Sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these items would be expended (beyond the foraging depths of bottom feeding turtles). If material is ingested, most 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. Therefore, adverse effects resulting from the ingestion of expended materials is considered extremely unlikely and thus the effects on sea turtles from ingestion is considered discountable for the following ESA-listed sea turtles: Central North Pacific, Central West Pacific and East Indian – West Pacific DPSs of green turtles; hawksbills; leatherbacks; and North Pacific DPS of loggerhead.

Stressors Resulting in Effects to Sea Turtle Habitat or Prey

Stressors from training and testing activities that could result in secondary effects on sea turtles via impacts to habitat, prey, sediment, and water quality include explosives and byproducts, metals, chemicals, and other expended materials.

Underwater explosions could impact other species in the food web, including prey species that sea turtles feed upon. 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. 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. Any of these scenarios would likely be short-term and temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected. In addition, the impacts of explosions would differ depending on the type of prey species in the area of the blast. Since many sea turtles feed primarily on algae and seagrasses (e.g., green sea turtles) or invertebrates (e.g., hawksbills, leatherbacks), their prey is less likely to be affected by explosions. For the reason state above, the indirect effects of explosives on ESA-listed sea turtles via impacts on turtle prey species are insignificant.

Effects of explosives and unexploded ordnance on sea turtles via sediment is possible in the immediate vicinity of the ordnance. High-order explosions (i.e., a successful explosion or an explosion that produces the intended result) consume almost all of the explosive material in the ordnance, leaving little to no material in the environment that could potentially affect marine species or their habitats. On the other hand, low order detonations and unexploded munitions

leave more explosive material in the environment. Lotufo et al. (2010) studied the potential toxicity of Royal Demolition Explosive byproducts to marine organisms. The authors concluded that degradation products of 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 background beyond three to six feet from the degrading munitions. Taken together, it is possible that ESA-listed sea turtles could be exposed to degrading explosives, but it would be within a very small radius of the explosive (one to six feet).

FDM has been used by the Navy as a target area since 1971. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long term look at potential impacts on the marine life from training and testing involving the use of munitions (Smith and Marx Jr. 2016). Munitions use has included high-explosive rounds from gunfire, high-explosives bombs by Navy aircraft and U.S. Air Force B-52s, in addition to the expenditure of inert rounds and non-explosive practice bombs. Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, and bony fish, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the biological resources had been adversely impacted to a significant degree by the training activities (Smith and Marx Jr. 2016). Furthermore, they found that the health, abundance, and biomass of fish, corals and other marine resources were comparable to or better than those in similar habitats at other locations within the Mariana Archipelago. The concentration of munitions/explosions, expended material, or devices in other locations throughout the Action Area are, in general, expected to be an extremely small compared to sites surveyed around FDM (as described above). As a result, explosion by-products and unexploded munitions are not anticipated to have significant adverse effects on water quality or prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on ESA-listed sea turtles via impacts to sediment and water quality are considered insignificant.

Metals may be introduced into seawater and sediments as a result of Navy training and testing activities involving ship hulks, targets, munitions, and other military expended materials. Sea turtles could be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. A variety of heavy metals have been found in sea turtles tissues in levels that increase with turtle size. These include arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc, (Barbieri 2009; Fujihara et al. 2003; García-Fernández et al. 2009; Godley et al. 1999; Storelli et al. 2008). Cadmium has been found in leatherbacks at the highest concentration compared to any other marine vertebrate (Gordon et al. 1998).

Evidence from a number of studies indicate metal contamination is highly localized and that bioaccumulation resulting from munitions cannot be demonstrated (Briggs et al. 2016; Edwards

and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013c). Specifically, in sampled marine life living on or around munitions on the seafloor, metal concentrations could not be definitively linked to the munitions since comparison of metals in sediment next to munitions show relatively little difference in comparison to other "clean" marine sediments used as a control/reference (Koide et al. 2016). Research has demonstrated that some smaller marine organisms are attracted to metal munitions as a hard substrate for colonization or as shelter (Kelley et al. 2016; Smith and Marx Jr. 2016). It is extremely unlikely that sea turtles would be indirectly impacted by toxic metals via the water. The research cited above indicates that metals introduced into the Action Area are unlikely to result in significant impacts to sea turtle prey or habitat. For these reasons, the effects of metals introduced into seawater and sediments on ESA-listed sea turtles via impacts to prey or habitat are insignificant.

Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed sea turtles 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 does not bioconcentrate or bioaccumulate, which is 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 sea turtle prey or habitat. In summary, the effects of chemicals used during Navy training and testing on ESA-listed sea turtles via water quality and prey are considered discountable.

8.1.3 Fishes

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed giant manta ray, oceanic whitetip shark, and Indo-West Pacific DPS scalloped hammerhead shark. As noted above, our analysis for these stressors is organized on the taxa level (i.e., fish) because the pathways for effects for these stressors is generally similar for all fish and we would not expect different effects at the species level. While there is variation among species within each taxa, the fish species considered in this opinion share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action. Where species-specific information is relevant,

this information is provided in this section. Our analysis for these stressors and effects on fish is summarized below.

Acoustic Stressors – Fishes

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed fish. Additional discussion of the acoustic stressors associated with the proposed action is included in Section 5.1 above. The effects of other acoustic stressors, which NMFS determined were likely to adversely affect ESA-listed fish, are discussed in Section 8.2.3.

Effects of Vessel Noise on Fish

ESA-listed fish considered in this biological opinion may be exposed to sound from vessel movement during Navy training and testing activities. In general, information regarding the effects of vessel noise on fish hearing and behaviors is limited. Some TTS has been observed in fish exposed to elevated background noise and other white noise, a continuous sound source similar to noise produced from vessels. Caged studies on sound pressure sensitive 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. 2006; Smith et al. 2004). 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 an SPL of 170 dB re 1 μPa and found a clear relationship between the amount of TTS and duration of exposure, until maximum hearing loss occurred at about 24 hours of exposure. A short duration (e.g., 10-minute) exposure resulted in five 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. 1998; Engas et al. 1995; Mitson and Knudsen 2003). Physiological responses have also been documented for fish exposed to increased boat noise. Nichols et al. (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. Navy vessels produce moderate to low-level passive sound sources (larger Navy 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 Navy 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 vessel noise would be intermittent, temporary and localized, and such responses would not be expected to compromise the general health or condition of individual fish from continuous exposures. Instead, the only impacts expected from exposure to Navy vessel noise for fish may include temporary auditory masking, physiological stress, or minor changes in behavior.

Therefore, similar to marine mammals and sea turtles, exposure to vessel noise for 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, the likely effects from exposure to vessel noise (i.e., short-term physiological stress, masking, or behavioral reactions), on Indo-West Pacific DPS scalloped hammerhead sharks, giant manta rays, and oceanic whitetip sharks are considered insignificant, and thus are not likely to cause adverse effects.

Effects of Aircraft Noise on Fish

All ESA-listed fish species considered in this biological opinion (scalloped hammerhead shark, giant manta ray, and oceanic whitetip shark) could be exposed to aircraft-generated overflight

noise throughout the Action Area. Sound transmission into deep depths of the water column is not likely, and sound that is transferred into the water from air is only within a narrow cone under the aircraft. Therefore, only fish located at or near the surface of the water and within the limited area where transmission of aircraft noise is expected to occur have the potential to detect any noise produced from low-flying aircraft. Most aircraft would quickly pass overhead, with helicopters potentially hovering for a few minutes or up to a few hours over the water's surface.

Direct injury and hearing impairment in fish 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 fish underwater. Furthermore, due to the brief and dispersed nature of aircraft overflights, masking of biologically relevant sounds for fish is also extremely unlikely. In the rare circumstance a fish detects sound produced from an aircraft overhead, only a very brief startle or avoidance response would be expected. Additionally, due to the short-term, transient nature of aircraft noise, ESA-listed fish are unlikely to be exposed multiple times within a short period of time that could lead to ongoing behavioral disruptions or stress. Any physiological stress and behavioral reactions would likely be short-term (seconds or minutes) and are expected to return to normal shortly after the aircraft disturbance ceases. Therefore, the effects on fish from aircraft overflight noise are anticipated to be minor, temporary and will not 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 aircraft overflight noise on Indo-West Pacific DPS scalloped hammerhead sharks, giant manta rays, and oceanic whitetip sharks are considered insignificant, and thus are not likely to cause adverse effects.

Effects of Weapons Firing, Launch, and Impact Noise on Fish

ESA-listed fish at the surface of the water could be exposed to weapons noise, 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 fish 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 fish 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 fish, 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 fish. 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 fish is also extremely unlikely. As with the other stressors for fish 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, fish 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 fish from weapons noise are anticipated to be minor, temporary, and are not expected 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 weapons noise on scalloped hammerhead sharks, giant manta rays, and oceanic whitetip sharks are considered insignificant, and thus are not likely to cause adverse effects.

Effects of Explosions in Air on Fish

Explosions that occur during air warfare would typically be at sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude and would not reach the water's surface where ESA-listed species could occur. Fish within the audible range of sound from explosions in air may exhibit a behavioral startle response but are expected to quickly return to normal behavior. Due to the short duration and sporadic nature of explosions in the air and the extremely low likelihood of an ESA-listed animal being within close enough proximity to detect sounds from such explosions, we do not expect this stressor would result in a significant disruption of normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Therefore, the effects of sound from explosions in air on Indo-West Pacific DPS scalloped hammerhead sharks, giant manta rays, and oceanic whitetip sharks would be insignificant, and thus are not likely to cause adverse effects.

Effects of Sonar and Transducers on Fish

All ESA-listed fish considered in this opinion have the potential to be exposed to sonar and other transducers during Navy activities in the action area. These types of sound sources are considered to pose less risk to fish species because the sound produced from sonar characteristically has lower peak pressures and slower rise times than other acoustic stressors that are known to injure fish such as impulsive sounds from pile driving, or the strong shock waves produced from detonation of explosives. Direct injury from sound levels produced from the type of sonar the Navy uses has not been documented in fish (Halvorsen et al. 2012; Kane et al. 2010; Popper et al. 2007; Popper et al. 2013). However, some hearing impairment could occur, as well as behavioral and stress responses which are discussed below.

As described previously, fish are not equally sensitive to noise at all frequencies. Some species of fish have specialized adaptations which increases their ability to detect sounds at higher frequencies. In general, fish with swim bladders are considered more sensitive to sound than fish without swim bladder. None of the ESA-listed fish species considered in this opinion (oceanic whitetip shark, giant manta ray, and scalloped hammerhead sharks) have a swim bladder or possess hearing specializations. For these elasmobranch species (without a swim bladder) hearing capabilities are limited to particle motion detection at frequencies well below two kHz.

Several shark species, including the oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*), have been observed withdrawing from pulsed low-frequency sounds played from an underwater speaker (Klimley and Myrberg 1979; Myrberg et al. 1978). Lemon sharks exhibited withdrawal responses to pulsed low to mid-frequency sounds (500 to 4,000 Hz) raised 18 dB at an onset rate of 96 dB/sec to a peak amplitude of 123 dB RL from a continuous level, just masking broadband ambient noise (Klimley and Myrberg 1979). In their study, lemon sharks withdrew from artificial sounds which included ten pulses/second (continuous), ten pulses/second (intermittent), and 15 to 7.5 decreasing pulses/second (intermittent). Myrberg et al. (1978) reported that a silky shark withdrew 10 m (33 ft) from a speaker broadcasting a 150 to 600 Hz sound with a sudden onset and a peak SL of 154 dB. These sharks avoided a pulsed low frequency attractive sound when its sound level was abruptly increased by more than 20 dB. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. These results do not rule out that such sounds may have been harmful to them after habituation; the tests were not designed to examine that point. Klimley (unpublished data) also noted the increase in tolerance of lemon sharks during successive sound playback tests. The pelagic whitetip (*Carcharhinus longimanus*) also showed a withdrawal response during limited tests (Myrberg et al. 1978).Some sharks are attracted to pulsing low-frequency sounds. Myrberg (2001) stated that sharks have demonstrated highest sensitivity to low-frequency sound (40 to 800 Hz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hz and transmitted suddenly without an increase in intensity, thus resembling a struggling fish. However, these signals are substantially different from the low-frequency active sonar signals produced during Navy testing activities.

No studies have indicated any physiological damage to adult fish from mid-frequency sonar. However, studies on juvenile herring survival following intense sonar exposures affected less than 0.3 percent of the total juvenile stock (Kvadsheim and Sevaldsen 2005). Similarly, Jorgensen et al. (2005) exposed larvae and juvenile fish of Atlantic herring (*Clupea harengus*) Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*), and spotted wolffish (*Anarhichas minor*) to sounds that were designed to simulate mid-frequency 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 three meters from the sound source and exposed to between four and 100 pulses of one-second duration of pure tones at 1.5, 4, and 6.5 kHz. The fish in only two

groups, out of the 42 tested, exhibited adverse effects beyond a behavioral response. These two groups were both composed of herring (a fish with hearing specializations and a swim bladder), and were tested with SPLs of 189 dB re 1 μPa, which resulted in a post-exposure mortality of 20 to 30 percent. In the remaining 40 tests, there were no observed effects on behavior, growth (length and weight), or the survival of fish that were kept as long as 34 days post exposure. While statistically significant losses were documented in the two groups impacted, the researchers only tested that particular sound level once, so it is not known if this increased mortality was due to the level of the test signal or to other unknown factors. It is also important to note, that none of the ESA-listed fish species considered in this biological opinion have the hearing specializations similar to herring, as such are not considered as sensitive to sound exposures and associated hearing damage as herring.

In another 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 uPa, resulting in cumulative SELs of 220 dB re 1 uPa. The researches did not observe any mortality or hearing sensitivity changes in rainbow trout and suggested that the frequency range of mid-frequency active sonar may be above the most sensitive hearing range of the species.

Some studies have suggested that there may be loss of sensory hair cells due to high intensity sources; however, none of these studies concurrently investigated effects on hearing. Enger (1981) found loss of ciliary bundles of the sensory cells in the inner ears of Atlantic cod following one to five hours of exposure to pure tone sounds between 50 and 400 Hz with an SPL of 180 dB re 1 μPa. Similarly, Hastings (1995) found auditory hair-cell damage in a species with notable anatomical hearing specializations, the goldfish (*Carassius auratus*) exposed to 250 Hz and 500 Hz continuous tones with maximum peak levels of 204 dB re 1 μPa and 197 dB re 1 μPa, respectively. Compared to Navy sonar exposures 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 fish 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) also demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) following a 1-hour exposure to a pure tone at 300 Hz with a peak pressure level of 180 dB re 1 μPa. Although in none of the studies was the hair cell loss more than a relatively small percent (less than a maximum of 15 percent) of the total sensory hair cells in the hearing organs.

Hastings (1990) and Hastings (1995) 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 μPa. However, this species of fish has an air bubble in the mouth cavity directly adjacent to the animal's braincase that may have caused this injury. The researchers also found that goldfish exposed to two hours of continuous wave sound at 250 Hz with peak pressures of 204 dB re 1 μPa, and fathead minnows exposed to 0.5 hours of 150 Hz

continuous wave sound at a peak level of 198 dB re 1 μPa did not survive. The only study on the effect of exposure of the lateral line system to continuous sound was conducted on a freshwater species, and suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

The research described above, and the most recent literature review and summary completed by Popper et al. (2014) regarding fish response to low-frequency and mid-frequency 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. However, the research conducted to date has not provided evidence that injury or mortality could occur from Navy sonar. Although fish 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 Navy's proposed activities. Moreover, if injury or mortality occurs, it is thought to begin at higher sound levels than have been tested to date. In addition, the relative risk of injury or mortality to fish with no swim bladders exposed to low and mid-frequency sonar is lower than fish with swim bladders, no matter the distance from the source.

Based upon the fish hearing and frequency overlap, the ESA-listed fish considered in this biological opinion would likely be able to detect most of the Navy sonars within the low-frequency active sonar ranges but would not be able to hear Navy sonars or other transducers with operating frequencies greater than about one to two kHz.

The recommended criteria and thresholds in the 2014 ANSI Guidelines are used to predict potential impact to fish from sonar and transducers (described in detail Section 2.2.7). As described above, mortality or injury from exposure to sonar is highly unlikely for the fish species potentially present in the action area. Fish without a swim bladder (e.g., elasmobranchs) are less susceptible to noise exposure, therefore TTS is unlikely to occur, and no criteria have been proposed. Thus, the most probable effects to ESA-listed species considered in this opinion would be masking, physiological stress and behavioral responses.

Exposure of scalloped hammerhead sharks, oceanic whitetip sharks, and giant manta rays to acoustic stressors could not be quantitatively assessed due to limited information on species distribution and density in the action area. As discussed above, these species are likely only capable of detecting sounds from low-frequency sources. The Navy has proposed a total of only 11 hours of low-frequency acoustic sources (bins LF4 and LF5 combined) per year during MITT Phase III activities (down from 174 hours during Phase II). Given this low level of activity and anticipated low densities of ESA-listed fish in areas where low-frequency sources would be used, we expect a very low number of exposures to occur. The duration and intensity of low-frequency non-impulsive acoustic stressors and the lack of a swim bladder will likely minimize the effect this stressor has on sharks and rays that are exposed.

Sharks and rays that are able to detect low-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 significant responses, whereas fish located further away from the source are less likely to react to the sound levels. However, because the Navy's sonar is moving, and fish are also capable of moving away from the disturbance, the overall exposure duration is expected to be brief. If masking did occur, it would not occur for a significant amount of time and not prevent fish from detecting biologically relevant cues at meaningful levels. Additionally, any physiological stress responses or behavioral reactions would also be expected to be temporary, lasting only a few seconds or minutes during sonar pings. For these reasons, no long-term consequences for any exposed shark or ray are expected. 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. Therefore, the effects of sonars and transducers are considered insignificant, and thus are not likely to cause adverse effects, for giant manta ray, oceanic whitetip shark, and Indo-West Pacific DPS scalloped hammerhead shark.

Effects of Explosive Sources Not Quantitatively Analyzed

In addition to the explosives quantitatively analyzed for impacts to ESA-listed species (shown in Table 23 above), the Navy uses some very small impulsive sources (less than 0.1 lb. NEW), categorized in bin E0, that were not quantitatively analyzed by the Navy for potential exposure to ESA-listed species. Quantitative modeling in multiple locations has indicated that these sources have a very small zone of influence. As such, it is extremely unlikely that the ESA-listed fish considered in this opinion would be exposed to explosives in bin E0. Therefore, potential effects from explosives in bin E0 on ESA-listed fish are discountable.

Energy Stressors – Fishes

This section analyzes the effects of energy stressors used during training and testing activities on fish within the action area. Additional discussion on energy stressors is included in Section 5.2. This section includes analysis of the potential impacts of: 1) in-water electromagnetic devices; and 2) high-energy lasers.

Effects of In-water Electromagnetic Devices on Fish

A synthesis of information provided by Normandeau et al. (2011) provides a comprehensive review of information regarding the sensitivity of marine organisms to electric and magnetic impulses. Available data suggests that while many fish species (particularly elasmobranchs) are sensitive to electromagnetic fields (Hore 2012), more research is necessary to understand the physiological response and magnitude of the potential impacts from these sources on fish.

Many fish groups (including elasmobranchs) have been demonstrated to have an acute sensitivity to electrical fields, known as electroreception (Bullock et al. 1983; Helfman et al. 2009). Fish are thought to use the same sensory organs used for near field water motion and sound pressure (e.g.,

lateral line system) for electroreception. In general, fish possess two types of electroreceptor organs: (1) ampullary receptors within the skin, which are connected to the surface by a canal filled with a conductive gel that is sensitive to electric fields of low-frequency (less than 0.1 to 25 Hz) and (2) tuberous receptors, embedded in the epidermis, and are covered with loosely packed epithelial cells; these receptors detect higher frequency electric fields (50 Hz to greater than two kHz) (Helfman et al. 2009). The distribution of electroreceptors on the head, and especially around the mouth, suggests that these sensory organs may be used in foraging and perhaps social communication (Collin and Whitehead 2004).

Each ESA-listed fish potentially exposed to this stressor has some level of electroreception capabilities. Elasmobranchs (including scalloped hammerheads, oceanic whitetip sharks, and giant manta rays) are well known to be sensitive to electromagnetic fields compared to other fish species. Some elasmobranch species have small pores near the nostrils, and around the head and on the underside of the rostrum, called ampullae of Lorenzini, which detect the electromagnetic signature of their prey. Electroreceptors are also thought to aid in navigation, orientation, and migration of sharks and rays (Kalmijn 2000). In elasmobranchs, behavioral and physiological response to electromagnetic stimulus varies by species and age, and appears to be related to foraging behavior (Rigg et al. 2009). These species are known to respond physiologically to electric fields of ten nanovolts per cm and behaviorally at five nanovolts per cm (Collin and Whitehead 2004). Kajiura and Holland (2002) demonstrated juvenile scalloped hammerhead sharks were able to detect and respond to electric fields of less than one nanovolt per cm. Other studies suggest that sharks are attracted to electromagnetic sources when conditions in the water hinder their other senses such as sight and hearing (Fields 2007).

In a controlled laboratory study, the scalloped hammerhead *(Sphyrna lewini*) and sandbar sharks (*Carcharhinus plumbeus*) exhibited altered swimming and feeding behaviors in response to very weak electric fields (less than 1 nanovolt per cm; Kajiura and Holland 2002). Five Pacific sharks were shown to react to magnetic field strengths of 2,500 to 234,000 μT at distances ranging between 0.26 and 0.58 m and avoid the area (Rigg et al. 2009). Similarly, southern stingrays (*Dasyatis americana*) and nurse sharks (*Ginglymostoma cirratum*) have been demonstrated to detect and avoid a fixed magnetic field producing a flux of 95,000 μT (O'connell et al. 2010). White sharks (*Carcharodon carcharias*) have also been shown to alter behavior when approaching a towed prey item with an active electromagnetic field (Huveneers et al. 2013). For comparison, the researchers also exposed sharks to static prey items and no behavioral alterations were observed, indicating the sharks were able to detect the electromagnetic field of the towed prey.

Although some individual fish species may exhibit a response to electromagnetic exposure, the fields generated are typically well below physiological and behavioral responses of magnetoreceptive fish. The strength of the electromagnetic devices used by the Navy is relatively

minute and quickly dissipates at short distances away from the source. The devices work by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The magnetic field away from the device is comparable to the Earth's magnetic field (see sea turtle section above). Based on the small area around each electromagnetic device that will have an altered magnetic field, we assume that any potential disruption in an individual fish's orientation ability in the action area would only occur very close to the source. Additionally, this disruption would be temporary and last only as long as the fish remains within the area where the magnetic field is altered, which is likely to be very brief. Furthermore, most fish would be expected to avoid the device prior to entering the area where the magnetic field would be altered. We considers it extremely unlikely that ESA-listed fish would be exposed to electromagnetic energy at sufficient intensities to create an adverse effect through behavioral disruption or otherwise. Therefore, the effects electromagnetic devices on giant manta ray, oceanic whitetip shark, and Indo-West Pacific DPS scalloped hammerhead shark are discountable.

Effects of Lasers on Fish

High-energy laser weapons would be used for testing activities in the action area. Fish could be exposed to a laser only if the beam missed the target. Should the laser strike the sea surface, individual fish at or near the surface could be exposed. The potential for exposure to a high-energy laser beam decreases as the water depth increases. Most fish are unlikely to be exposed to laser activities because these species primarily occur more than a few meters below the sea surface.

Oceanic whitetip sharks and giant mantas are found in offshore locations and occur near the surface of the water column so may pose a higher risk of being exposed to high-energy lasers. However, it is extremely unlikely that an individual would surface at the exact moment in the exact place that the laser misses its target and hits the surface. ESA-listed fish are extremely unlikely to be exposed to high-energy lasers based on 1) the relatively low number of events per year, 2) the very localized potential impact area of the laser beam, 3) the temporary duration of potential impact (seconds), 4) the low probability of fish at or near the surface at the exact time and place a laser misses its target, 5) the low probability of a laser missing its target; and 6) the low density of ESA-listed fish species in the marine areas where activities using lasers are conducted. Therefore, the effects from high-energy lasers on giant manta ray, oceanic whitetip shark, and Indo-West Pacific DPS scalloped hammerhead shark are discountable.

Physical Disturbance and Strike Stressors – Fish

Additional discussion on physical disturbance and strike stressors is included in Section 5.3. This section analyzes the potential impacts of the various types of physical disturbance, including the potential for strike, during training and testing activities within the action area from vessels and in-water devices; military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions; and seafloor devices.

Effects of Vessels and In-water Devices on Fish

Vessel traffic and in-water device use during Navy training and testing activities would primarily occur in certain portions of the Action Area such as areas near ports (e.g., Apra Harbor, Guam) or naval installations and ranges, but could occur throughout the Action Area. Each of the ESA-listed fish 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. Though tagging studies indicate giant manta rays are capable of descending to depths of hundreds of meters, they are also known to occur in surface waters where they may be susceptible to vessel strike.

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 the ESA-listed fish considered in this opinion would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). 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 ship showed avoidance reactions at ranges of 160–490 ft (50–350 m). When the vessel passed over them, some fish responded with sudden escape responses that involved movement away from the vessel laterally or through downward compression of the school. Regardless of the response, there is the potential for some type of stress or energetic cost as an individual fish must stop its current activity and divert its physiological and cognitive attention to responding to the vessel (Helfman et al. 2009). 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.

Given the low abundance of the ESA-listed fish species in the action area, particularly around Navy ports or Naval installations, the ability of these species to maneuver to avoid any oncoming vessels, the low number of vessels associated with MITT activities relative to non-military traffic in the area, and the lack of documented cases of Navy vessels or in-water devices striking these species (or any other fish species) in the action area, it is extremely unlikely that a Navy vessel associated with MITT activities will strike an ESA-listed species. 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 Indo-West Pacific DPS scalloped hammerhead shark from vessels and in-water devices are discountable (in the case of strikes) or insignificant (in the case of behavioral response), and thus are not likely to cause adverse effects.

Effects of Military Expended Materials on Fish

This section analyzes the strike potential to ESA-listed fish species from military expended materials including the following: 1) all sizes of non-explosive practice munitions, 2) fragments from high-explosive munitions, 3) expendable targets and target fragments; and 4) expended materials other than munitions, such as sonobuoys, expended bathythermographs, and torpedo accessories. While no strike of ESA-listed fish species from military expended materials has ever been reported or recorded, the possibility of a strike still exists. However, given the large geographic area involved and the relatively low densities of ESA-listed fish species in the action area, we do not believe such interactions are likely.

ESA-listed fish species are not common in the action area and are anticipated to occur in very low densities, similar to ESA-listed cetaceans. For this reason, we anticipate a similarly low likelihood that Navy military expended materials would directly strike an ESA-listed fish species in the action area. Additionally, while disturbance or strike from any expended material as it falls through the water column is possible, it is not likely because the objects will slow in velocity as they sink toward the bottom (e.g., guidance wires sink at an estimated rate of 0.7 ft [0.2 m] per second; heavier items such as non-explosive munitions would likely sink faster, but would still be slowed as they sink to the bottom), and can be avoided by highly mobile organisms such as sharks and rays.

In summary, it is extremely unlikely that a giant manta ray, oceanic whitetip shark, or Indo-West Pacific DPS scalloped hammerhead shark will be struck by military expended materials and the effects are therefore discountable. 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, and thus are not likely to cause adverse effects.

Effects of Seafloor Devices on Fish

The types of activities that use seafloor devices include items placed on the seafloor, dropped on the seafloor, or that move along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed instruments, and bottom-crawling unmanned underwater vehicles (Navy 2018b). The likelihood of any ESA-listed species encountering seafloor devices is considered very low given the likely densities of these species near the seafloor and in areas where such devices would be found. If encountered, sharks and rays would be expected to ignore or avoid any slowly moving or stationary device on the seafloor. In summary, we find that the likelihood of exposure to adverse effects from seafloor devices is extremely unlikely, and thus discountable for giant manta ray, oceanic whitetip shark, and Indo-West Pacific DPS scalloped hammerhead shark.

Entanglement Stressors – Fish

Some fish species are more susceptible to entanglement in derelict fishing gear and other marine debris, compared to other fish groups. For example, the shape of the body of some elasmobranchs such as manta rays, increase their risk of entanglement compared to other, more

streamlined fish. For many pelagic species, including oceanic whitetip sharks and scalloped hammerhead sharks, the risk of entanglement is unlikely given their body shape and ability to avoid materials that could entangle them in the water column.

Although some species of fish could become entangled in the guidance wires and fiber optic cables, the risk for most of the fish species is considered low. A portion of the fiber optic cable may be recovered, but some used for remotely operated mine neutralization activities would not. The length of this expended tactical fiber would vary (See Section 5.4.1) depending on the activity. Tactical fiber has an 8 µm (0.008 mm) silica core and acylate coating and looks and feels like thin monofilament fishing line; tactical fiber is relatively brittle and breaks if knotted, kinked, or abraded against a sharp object (Navy 2018b). Therefore, if this becomes looped around an underwater object or animal, it is unlikely to tighten. Although this material will not be recovered, it is expected to only remain in the water column for a short duration, and ultimately sink. Similarly, once a guidance wire is released it is expected to rapidly sink, settle and remain on the seafloor. If a wire were to snag or be partially resuspended, in theory a fish could swim through loops in the wire that may entangle the fish. However, because of their rigidity and size, loops are less likely to form in a guidance wire or sonobuoy wire (Environmental Sciences Group 2005). Torpedo guidance wire is resistant to looping and coiling, suggesting it has a low entanglement potential compared to other entanglement hazards (Swope & McDonald, 2013. Similarly, fiber optic wire material is more resistant to forming loops and would easily break when tightly kinked or bent at a sharp angle. This is in contrast to fishing gear materials which are more common entanglement threats for fish and have breaking strengths much greater than that of guidance wire and fiber optic cables used during Navy activities.

Similarly, sonobuoy surface antenna, float unit, and subsurface hydrophone are attached through a thin gauge, dual-conductor, and hard-draw copper strand wire; which is wrapped by a hollow rubber tubing or bungee. The tensile breaking strength of the wire and rubber tubing is no more than 40 lb. The length of the cable is housed in a plastic canister dispenser, which remains attached upon deployment. The length of wire that extends out is no more than 1,500 ft and is dependent on the water depth and type of sonobuoy. Attached to the wire is a kite-drogue and damper disk stabilizing system made of non-woven nylon fabric. This nylon fabric is very thin and can be broken by hand; therefore, it does not pose a risk of entanglement for fish. Sonobuoys may remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor. Sonobuoy wires may be expended within any of the range complexes throughout the Action Area. However, the wire that runs through the stabilizing system and leads to the hydrophone components of the sonobuoy hangs vertically in the water column, reducing the risk of ESA-listed fish becoming entangled.

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. Throughout the Action Area, the vast majority of expended decelerator and parachutes are small (18 inches) cruciform shaped decelerators used with sonobuoys. They have short attachment lines and, upon water impact, may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor. Entanglement of an animal in a parachute assembly at the surface or within the water column would be unlikely, since the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. For the large and extra-large decelerator and parachutes, that are unweighted and have multiple long lines attached to them, the chance of an entanglement is greater for giant manta rays, which are known to be susceptible to entanglement in fishing gear (83 FR 2916). A study in Hawaii found ten percent 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. 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 area. Furthermore, these small and medium decelerators and parachutes have weights attached, causing a more rapid sink rate, thereby decreasing the amount of time materials float at the surface, reducing the risk of a giant manta ray encountering them.

The large and extra-large decelerators and parachutes may pose a higher degree of risk for manta rays 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 (i.e., ten annually) of the large or extra-large parachutes proposed to be deployed and the anticipated low abundance of this species 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 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 practicable 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 (Ocean Conservancy 2010; U.S. Department of the Navy 2001). While NMFS recognizes there is a higher risk of entanglement for giant manta rays than for other fish species, 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. Therefore due to the low probability of a giant manta ray becoming entangled in parachutes and decelerators, it is extremely unlikely that effects from entanglement will occur from this stressor for giant manta rays.

In summary, for the reasons discussed above, the likelihood of ESA-listed fish species becoming entangled with material such as parachutes, decelerators, cables, or wires is extremely unlikely. Therefore, we consider the effects from entanglement stressors on giant manta rays, oceanic whitetip sharks, and Indo-West Pacific DPS scalloped hammerhead sharks to be discountable.

Ingestion Stressors – Fish

ESA-listed fish occurring in the action area could potentially ingest military expended materials resulting from MITT activities. The Navy expends the following types of materials during training and testing in the action area that could become ingestion stressors: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, and fragments from targets, chaff, flare casings (including plastic end caps and pistons).

As an open-ocean, pelagic species, oceanic whitetip sharks are more likely to ingest expended materials floating in the water column. Military expended materials that could potentially impact pelagic species that feed at or just below the surface or in the water column include those items that float or are suspended in the water column for some period of time (e.g., end caps and pistons from chaff cartridges or flares). If an oceanic whitetip shark accidentally ingested such an item at or near the surface it would likely expel it after determining it was not a prey item. Expended materials made of metal would sink quickly through the water column before settling on the seafloor. Once the item sinks to the seafloor, it would be unavailable to oceanic whitetip sharks. Shiny fragments of sinking munitions in the water column could potentially attract and be ingested by fast, mobile predators that chase moving prey. However, this is an unlikely scenario considering: 1) the small amount of time such objects would be in the water column and, 2) that highly mobile predators, such as oceanic whitetips sharks, would be expected to evacuate an area where an explosion has just occurred. In addition, oceanic whitetip sharks are relatively rare and dispersed throughout the Action Area, which further decreases the likelihood that one would encounter sinking expended materials in the water column.

Scalloped hammerheads generally occupy nearshore habitats within the action area and would, therefore, be less likely to encounter ingestible expended materials, which are more associated with offshore MITT activities. As discussed above, due to the size and composition of most material expended materials, the munitions and fragments would sink fairly rapidly to the seafloor, limiting the time available for encounter and ingestion by hammerhead sharks.

Giant manta rays are also an open ocean, pelagic species that feeds in the water column in areas where military expended materials could be found. However, as filter-feeders, manta rays are not expected to intentionally ingest munitions, and accidental ingestion of such materials is unlikely for a species that feeds on zooplankton.

For the reasons provided above, we consider it extremely unlikely that ESA-listed fish species would ingest materials resulting in adverse effects to the fish's normal behavior, growth, survival, or reproductive success. Therefore, we consider the effects from ingestion stressors on giant manta rays, oceanic whitetip sharks, and Indo-West Pacific DPS scalloped hammerhead sharks to be discountable.

Stressors Resulting in Effects to Fish Habitat or Prey

Stressors from training and testing activities that could result in secondary or indirect effects on ESA-listed fish via impacts to habitat, prey, sediment and water quality include explosives and byproducts, metals, chemicals, and other expended materials.

Underwater explosions could impact other species in the food web, including prey species that scalloped hammerheads and oceanic whitetip sharks feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. Since giant manta rays are filter feeders their prey is less likely to be affected by explosions. 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. 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. Any of these scenarios would likely be short-term and temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected. As highly mobile predators, oceanic whitetip sharks and scalloped hammerhead sharks would not likely be adversely affected by such short-term, localized impacts to their prey base. Thus, the effects of explosives on oceanic whitetip sharks and scalloped hammerhead sharks via impacts on their prey are considered insignificant. Since giant manta rays feed on plankton, their prey is even less likely to be affected by explosions. The effects of explosives on giant manta ray prey are, therefore, considered discountable.

FDM has been used by the Navy as a target area since 1971. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long term look at potential impacts on the marine life from training and testing involving the use of munitions

(Smith and Marx Jr. 2016). Munitions use has included high-explosive rounds from gunfire, high-explosives bombs by Navy aircraft and U.S. Air Force B-52s, in addition to the expenditure of inert rounds and non-explosive practice bombs. Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, and bony fish, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the biological resources had been adversely impacted to a significant degree by the training activities (Smith and Marx Jr. 2016). Furthermore, they found that the health, abundance, and biomass of fish, corals and other marine resources were comparable to or better than those in similar habitats at other locations within the Mariana Archipelago. The concentration of munitions/explosions, expended material, or devices in other locations throughout the Action Area are, in general, expected to be an extremely small compared to sites surveyed around FDM (as described above). As a result, explosion by-products and unexploded munitions are not anticipated to have significant adverse effects on water quality or prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on ESA-listed fish via impacts to sediment and water quality are insignificant, and thus are not likely to cause adverse effects.

It is extremely unlikely that fish would be indirectly impacted by toxic metals via the water. Certain metals are harmful to fish at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) (Wang and Rainbow 2008). 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). Fish may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Evidence from a number of studies (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013c) indicate metal contamination is 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 since comparison of metals in sediment next to munitions show relatively little difference in comparison to other “clean” marine sediments used as a control/reference (Koide et al. 2016). Research has demonstrated that some smaller marine organisms are attracted to metal munitions as a hard substrate for colonization or as shelter (Kelley et al. 2016; Smith and Marx Jr. 2016). The research cited above indicates that metals introduced into the Action Area are unlikely to result in significant impacts to ESA-listed fishes prey or habitat. For these reasons, the effects of metals introduced into seawater and sediments on ESA-listed fishes via impacts to prey or habitat are insignificant, and thus are not likely to cause adverse effects.

Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed fish or their prey. Chemicals

introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares, missiles, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment. Flares and missiles that operationally fail may release perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals if in sufficient concentration. However, such concentrations would be localized and are not likely to persist in the ocean. Research has demonstrated that perchlorate does not bioconcentrate or bioaccumulate, which is 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 fishes prey or habitat. In summary, the effects of chemicals used during Navy training and testing on ESA-listed fish via water quality and prey are considered discountable.

8.1.4 Corals

We determined that several of the acoustic stressors, all of the energy stressors, physical disturbance and strike stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect the ESA-listed coral *Acropora globiceps*. Previously, in Sections 6.1.2 and 6.1.3, we discussed why the other two coral species (*Acropora retusa* and *Seriatopora aculeata*) in the action area were not likely to be adversely affected by any of the potential stressors resulting from the Proposed Action. Our analysis for these stressors and *Acropora globiceps* is summarized below.

Effects of Vessel Noise on Corals

Adult coral colonies are not biologically capable of detecting noise except as vibrations of water particles. The only auditory sensing capabilities known for coral is the response of free-swimming coral larvae to underwater sounds produced by reef fish and crustaceans, as reported by Vermeij et al. (2010). The authors reported that some species of coral larvae detect reef sounds and then show an attraction response to the sounds generated on the reefs. However, potential interference in the ability of coral larvae to detect reef sounds would be temporary, lasting only the duration that the vessel is in the immediate vicinity of the larval coral. Since Navy vessels are generally transiting during training and testing, exposures and potential masking would be brief. 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 *A. globiceps* are considered minor and insignificant, and thus are not likely to cause adverse effects.

Effects of Cavitation from Vessels and In-Water Devices on Corals

Although the direct strike of adult coral reef colonies from Navy vessels is extremely unlikely and thus discountable, early life stages of corals could be exposed to the effects of vessel

movement in the action area. Corals broadcast spawn eggs and larvae into the water column where fertilization and early embryonic development occurs. Each individual coral polyp can produce 16 eggs and concentrations of sperm can be as high as one million parts per milliliter of seawater during spawning. The eggs, sperm, and larval stage of coral can remain in the water column for extended periods. Fertilized eggs develop into planula larvae within five days in *Acropora* species but these larvae can also remain in the water column over 200 days before settling.

Given the nature of coral spawning, Navy vessels and in-water devices could potentially pass through water containing eggs, sperm, early embryonic stages, or planula larvae of ESA-listed coral species. If this occurs, these life stages could be exposed to the effects of cavitation. Exposure to cavitation is most likely to occur near Guam and parts of the CNMI, where higher concentrations of Navy vessel traffic and early life stages of ESA-listed coral are more likely to be found. We assume that individuals in these life stages (eggs, sperm, early embryonic stages, or planula larvae) that occur offshore are less likely to come into contact with this stressor due to lower densities (greater volume of water), and a lower concentration of Navy vessel activity as compared to nearshore areas around Guam and CNMI. Life stages subjected to cavitation from vessels and in-water devices could be deformed, die, or experience a decreased likelihood of fertilization. However, the reproductive biology of coral species results in prolific larval production and high natural mortality from a combination of factors, including predation and dispersal to areas within the ocean without appropriate settlement habitat (e.g., deeper water, colder water, inappropriate substrate).

The eggs of *Acropora millepora*, a congeneric species of *Acropora globiceps*, are known to disintegrate into irregular groups or individual blastomeres when subjected to even very light shearing forces and turbulence (Heyward and Negri 2012). Under laboratory conditions these disintegrated cells commonly reorganized and continued development into eventual juveniles (Heyward and Negri 2012). Therefore, the disassociation of embryonic cells can be beneficial through the creation of more juveniles, although it is suspected others suffered direct mortality from being disassociated. In a manual for coral larvae rearing for reef rehabilitation, Guest et al. (2010), suggests rough handling of broadcast spawning coral embryos during early cell division stages (up to 36 hours post fertilization) will result in many embryo deaths or embryos being smaller than normal. Mead and Denny (1995) found turbulent water decreased successful fertilization of broadcast spawned eggs in the purple sea urchin, likely due to mechanical separation of eggs and sperm. The authors also found fertilized eggs exposed to high shear stresses of turbulent water showed abnormal development and low survival (Mead and Denny 1995). Shear stress from water turbulence has also been reported to cause increased mortality in fish eggs (Bunn et al. 2000; Eshenroder et al. 1994; Morgan et al. ; Sutherland and Ogle 1975).

Of the 19 threats to coral identified in the 2011 status review report of the 82 candidate coral species petitioned under the ESA (Brainard et al. 2011) and the top nine threats to coral analyzed in the final rule (79 FR 53851), none include mortality of larvae by physical disturbance (e.g.,

cavitation) from vessels. The areas used by the Navy for training and testing activities involving the use of vessels are only a small portion of the range of ESA-listed coral species in the action area and activities generally avoid areas where corals occur. Training and testing activities are not continuous and are not generally expected to correspond with coral mass spawning events. For these reasons, we believe the potential effect to ESA-listed coral larvae and future recruits of ESA-listed coral species resulting from the use of Navy vessels is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated), and thus are not likely to cause adverse effects.

Effects of Anchoring on Corals

There is evidence of anchor and/or anchor chain damage to coral in Apra Harbor. Movement of mooring chains on the southern side of the floating dry dock has produced a significant rubble field, although mooring chains on the northern (outer) side of the floating dry dock do not appear to have caused similar damage (DoN 2010a). However, available data suggests ESA-listed corals do not occur at existing Navy anchorages in Apra Harbor or other locations.

To avoid or reduce potential impacts on seafloor resources and their habitats, the Navy has proposed to continue implementation of the following mitigations:

- Within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks, the Navy will not conduct precision anchoring (except at designated anchorages and nearshore training areas around Guam and within Apra Harbor, where these resources will be avoided to the maximum extent practicable).
- Within a 350 yd radius of shallow-water coral reefs: The Navy will not place mine shapes, anchors, or mooring devices on the seafloor (except in designated locations, where these resources will be avoided to the maximum extent practicable

Given the low densities and patchy distribution of *A. globiceps* in the action area, and the proposed mitigation measures to protect seafloor resources, we consider the likelihood that anchors, anchor chains and mooring chains would adversely affect this species to be extremely unlikely and thus discountable.

Effects of Personnel Disturbance

Amphibious training activities conducted as part of the proposed action may involve military personnel walking, standing, or swimming in the shallow water through nearshore areas. Amphibious raids and assaults are planned to occur in areas that are primarily soft-bottom, sandy habitat (Navy 2019e). These activities could cause minor and temporary increases in suspended sediments in soft bottom habitats. The Navy conducts hydrographic surveys prior to amphibious assault and amphibious raid training activities involving beach landings by large amphibious vehicles (e.g., Air Cushioned Landing Craft). During the surveys, personnel identify and designate vessel traffic lanes that are free of coral, hard bottom substrate, and obstructions that could present personnel and equipment safety concerns. The Navy does not conduct hydrographic surveys for beach landings with small boats, such as Rigid Hull Inflatable Boats, which have a much smaller draft than large amphibious vehicles. Large amphibious vehicle

beach landings and departures are scheduled at high tide, and vehicles stay fully on cushion or hover when over shallow reefs to avoid corals, hard bottom, and other substrate that could potentially damage equipment. This standard operating procedure benefits seafloor resources and ESA-listed species that inhabit, shelter in, or feed among them, through a reduction in the potential for physical disturbance and strike during amphibious assault and amphibious raid activities. Based on the best available data on coral species distribution in the action area, and the likely location of MITT amphibious activities, we do not expect ESA-listed coral species to occur in areas proposed by the Navy for amphibious training activities. For this reason, we consider the likelihood of ESA-listed coral colonies being physically disturbed by Navy personnel to be extremely unlikely and thus discountable.

Effects of Entanglement Stressors on Corals

Fiber optic cables, guidance wires, and decelerators/parachutes will be used over deep water, long distances from habitat types where ESA-listed corals would occur within the MITT Action Area. For this reason, we consider the likelihood of *A. globiceps* colonies becoming entangled in fiber optic cables, guidance wires, decelerators/parachutes, or other expended materials from MITT activities to be discountable.

Stressors Resulting in Effects to Coral Habitat or Prey

This section analyzes potential impacts to the ESA-listed coral *A. globiceps* exposed to stressors indirectly through impacts to their habitat or prey. The stressors evaluated in this section include 1) explosives 2) explosive byproducts and unexploded munitions, 3) metals, 4) chemicals; and 5) transmission of disease and parasites.

Explosives

Underwater explosions could impact other species in the food web, including prey species (zooplankton) that *A. globiceps* may feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. The abundances of zooplankton near the detonation point could be diminished for a short period of time before being repopulated from adjacent waters. The effects of an explosion on plankton would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected. For this reason, the effects of chemicals used during MITT activities on the ESA-listed coral *A. globiceps* are insignificant, and thus are not likely to cause adverse effects.

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 potentially affect marine 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 coral *A. globiceps* could be exposed to degrading explosives, such exposure would likely only occur within a very small radius of the explosive.

Research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016) and an intensively used live fire range in the Mariana Islands (Smith and Marx Jr. 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life. Findings from these studies indicate that there were no adverse impacts on the local ecology from the presence of degrading munitions and there was no bioaccumulation of munitions-related chemicals in local marine species.

The island of FDM (in the CNMI) has been used as a target area since 1971. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long term look at potential impacts on the marine life from training and testing involving the use of munitions (Smith and Marx Jr. 2016). Munitions use has included high-explosive rounds from gunfire, high-explosives bombs by Navy aircraft and U.S. Air Force B-52s, in addition to the expenditure of inert rounds and non-explosive practice bombs. Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, and bony fishes, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the biological resources had been adversely impacted to a significant degree by the training activities (Smith and Marx Jr. 2016). Furthermore, they found that the health, abundance, and biomass of fishes, corals and other marine resources were comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago.

The concentration of munitions, explosives, expended material, or devices in any one location in the action area are expected to be a small fraction of that from the sites described above. As a result, explosion by-products and unexploded munitions are not anticipated to have adverse effects on water quality or prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions from MITT activities on the ESA-listed coral *A. globiceps* through impacts to prey or habitat are insignificant, and thus are not likely to cause adverse effects.

Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, munitions, and other military expended materials (Environmental Sciences Group, 2005). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Evidence from a number of studies (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016;

Navy 2013c) indicate metal contamination is 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 since comparison of metals in sediment next to munitions show relatively little difference in comparison to other "clean" marine sediments used as a control/reference (Koide et al. 2016). Research has demonstrated that some smaller marine organisms are attracted to metal munitions as a hard substrate for colonization or as shelter (Kelley et al. 2016; Smith and Marx Jr. 2016), but this would not have an effect on the availability of marine mammal prey. The research cited above indicates that metals introduced into the Action Area are unlikely to result in significant impacts to on the ESA-listed coral *A. globiceps* prey or habitat. For these reasons, the effects of metals introduced into seawater and sediments on *A. globiceps* via impacts to prey or habitat are insignificant, and thus are not likely to cause adverse effects.

Chemicals

Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed coral A. globiceps. 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 bioconcentrate 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 coral prey or habitat. In summary, the effects of chemicals used during Navy training and testing on *A. globiceps* via water quality and prey are considered discountable.

8.2 Stressors Likely to Adversely Affect ESA-Listed Species

We determined that the following stressors from the proposed action are likely to adversely affect ESA-listed species:

1) Acoustic stressors from sonar and other transducers – cetaceans;
2) Explosive stressors in water – cetaceans, sea turtles, fish and corals;
3) Physical disturbance and strike stressors from vessels – sea turtles.

The following sections describe the effects of these stressors on ESA-listed species. For each type of stressor, we 1) describe the potential adverse effects of the stressor, 2) summarize the exposure analysis which (where possible) estimates the number and life stages of individuals of each ESA-listed species that may be exposed to the stressor; and 3) provide our assessment of the likely responses these species would exhibit to this exposure.

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

8.2.1 Cetaceans

This section discusses the effects of sonar and other transducers and explosives on ESA-listed cetaceans.

Sonar and Other Transducers

As described further in Section 5.1.1, sonar and other transducers includes a variety of acoustic devices used to obtain and transmit information about the undersea environment. Some examples are: mid-frequency hull-mounted sonars used to find and track submarines; high-frequency small object detection sonars used to detect mines; high-frequency underwater modems used to transfer data over short ranges; and extremely high-frequency (greater than 200 kHz) Doppler sonars used for navigation, like those used on commercial and private vessels.

Assessing whether a sound may disturb or injure a cetacean involves understanding the characteristics of the acoustic sources, the cetaceans that may be present in the vicinity of the sources, and the effects that sound may have on the physiology and behavior of those cetaceans. Although it is known that sound is important for cetacean 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 cetaceans 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.

The potential effects of acoustic exposure range from physical injury or trauma, to an observable behavioral response, to a stress response that may not be detectable. Injury can occur to organs or tissues of an animal due to exposure to pressure waves. Non-auditory injury (i.e., other than PTS) and mortality from sonar and other transducers is considered so unlikely as to be

discountable under normal conditions, and is therefore not considered further in this opinion for marine mammals.[7] Noise-induced hearing loss is a decrease in hearing sensitivity, which can either be temporary or permanent. Stress can help an animal cope with changing conditions, but too much stress can result in negative physiological effects. Masking can occur when the perception or communication of a biologically-important sound is interfered with by a second sound (e.g., noise from Navy training and testing). Behavioral responses range from brief distractions to avoidance of a sound source to prolonged flight. The sections below provide additional background on the potential effects of sonar and other transducers on cetaceans. We use this information to discuss the likely effects of Navy sonar use on ESA-listed cetaceans in our exposure, response, and risk analyses that follow.

Hearing Loss and Auditory Injury

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss 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. Hearing loss has only been studied in a few species of cetaceans, although hearing studies with terrestrial mammals are also informative.

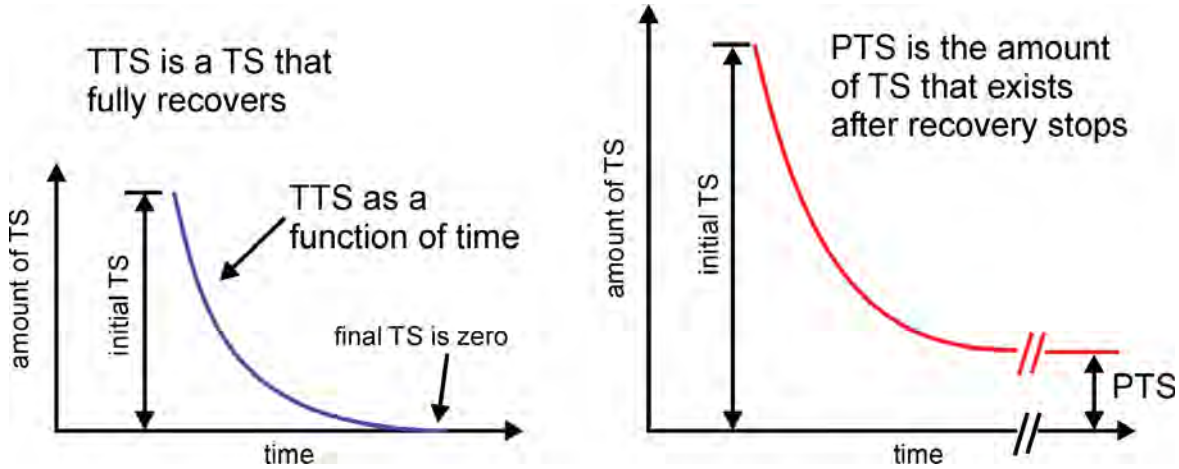


Figure 47: Two hypothetical threshold shifts.

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

TTS in mid-frequency cetaceans exposed to non-impulsive sound (e.g., active sonar tones) has been investigated in multiple studies (e.g., Finneran et al. 2010; Finneran et al. 2005; Finneran and Schlundt 2013; Mooney et al. 2009a; Mooney et al. 2009b) (Finneran et al. 2010; Kastelein et al. 2015c; Kastelein et al. 2014b; Mooney et al. 2009b)from three species, bottlenose dolphins (*Tursiops truncates*) and beluga whales (*Delphinapterus leucas*), and harbor porpoise (*Phocoena phocoena*) (Popov et al. 2017).

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 called a TTS. If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is called a PTS. Figure 47 shows two hypothetical threshold shifts: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.

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 hour 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 hour 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.

There are no simple functional relationships between TTS and the occurrence of PTS or other auditory injury (e.g., neural degeneration). TTS and PTS are mutually exclusive because an exposure that produces TTS cannot also produce PTS within the same frequency band in the same individual (Reichmuth et al. 2019). If an initial threshold shift results in only partial recovery, resulting in some amount PTS, the difference between the initial TS and the PTS is not called TTS. As TTS increases, the likelihood that additional exposure SPL or duration will result in PTS and/or other injury also increases, with the exception that researchers might not be able to observe gradual growth of TTS with increased levels of SEL before onset of PTS (Reichmuth et al. 2019). Similarly, PTS can occur without measurable behavioral modifications (Reichmuth et al. 2019). Exposure thresholds for the occurrence of PTS or other auditory injury can therefore be defined based on a specific amount of TTS. The specific upper limit of TTS is based on experimental data showing amounts of TTS that have not resulted in PTS or injury. In other words, we do not need to know the exact functional relationship between TTS and PTS or other injury. We only need to know the upper limit for TTS before some PTS or injury is possible.

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al. 1965; Ward 1960). It is reasonable to assume the same relationship would hold for cetaceans because there are many similarities between the inner ears of marine and terrestrial mammals. Experiments with cetaceans have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, drug-induced hearing loss, masking, and frequency selectivity (Finneran et al. 2005; Finneran et al. 2015; Ketten 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately 4 min after exposure represent the limit of a non-injurious exposure; i.e., higher level exposures have the potential to cause auditory injury. Exposures sufficient to produce a TTS of 40 dB, measured approximately 4 min after exposure therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS, or other auditory injury such as the delayed neural degeneration identified by (Kujawa and Liberman 2009) and Lin et al. (2011) that may not result in PTS.

Numerous studies have directly examined noise-induced hearing loss in cetaceans (See Finneran et al. 2015). In these studies, hearing thresholds were measured in cetaceans before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds was then used to determine the amount of TTS at various post-exposure times. The major findings from these studies include the following:

- The method used to test hearing may affect the resulting amount of measured TTS, with neurophysiological measures producing larger amounts of TTS compared to psychophysical measures (Finneran et al. 2007; Finneran et al. 2015).
- The amount of TTS varies with the hearing test frequency. The higher the SPL, the higher the TTS induced at frequencies higher than the exposure frequency; below 148 dB re 1 μPa, the maximum TTS was at 6.5 kHz, whereas above 148 dB re 1 μPa, the maximum TTS was at 9.2 kHz. (Kastelein et al. 2014b). For high level exposures to tonal or octave band sounds, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al. 2007; Mooney et al. 2009a; Nachtigall et al. 2004; Popov et al. 2013; Popov et al. 2011; Reichmuth et al. 2019; Schlundt et al. 2000). The overall spread of TTS from tonal exposures can therefore extend over a large frequency range; i.e., narrowband exposures can produce broadband (greater than one octave) TTS.
- The amount of TTS usually increases with exposure SPL and duration, and is correlated with SEL, especially if the range of exposure durations is relatively small (Kastak et al. 2007; Kastelein et al. 2014b; Popov et al. 2014). As the exposure duration increases, the relationship between TTS and SEL begins to break down. Specifically, duration has a more significant effect on TTS than would be predicted on the basis of SEL alone (Finneran and Schlundt 2010; Kastak et al. 2005; Mooney et al. 2009a). This means if two exposures have the same SEL but different durations, the exposure with the longer

duration (thus lower SPL) will tend to produce more TTS than the exposure with the higher SPL and shorter duration. In most acoustic impact assessments, the scenarios of interest involve shorter duration exposures than the cetacean experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.

- The amount of TTS depends on the exposure frequency. Sounds that are well below the frequency level of best sensitivity are less hazardous than those at or near the level of best sensitivity (Finneran and Schlundt 2013). The onset of TTS — defined as a threshold shift of six dB measured approximately four minutes after exposure (i.e., clearly above the typical variation in threshold measurements) — also varies with exposure frequency. At low frequencies TTS onset exposure levels are higher compared to those in the region of best sensitivity.
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al. 2010; Kastelein et al. 2015c; Kastelein et al. 2014b; Mooney et al. 2009b). This means that TTS predictions based on the total, cumulative SEL will likely overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., approximately 40 dB) may require several days or longer for recovery. Recovery times are consistent for similar-magnitude shifts, regardless of the type of fatiguing sound exposure (impulsive, continuous noise band, or sinusoidal) (Kastelein et al. 2019). Under many circumstances TTS recovers linearly with the logarithm of time (Dear et al. 2010; Finneran et al. 2010; Finneran and Schlundt 2013; Kastelein et al. 2013a; Kastelein et al. 2012a; Kastelein et al. 2012b; Kastelein et al. 2014b; Kastelein et al. 2014c; Popov et al. 2014; Popov et al. 2013; Popov et al. 2011). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., six dB recovery per doubling of time), although this may not hold for all sound sources and species.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of man-made sound sources have the potential to cause a threshold shift to a cetacean in the wild. These include some sonars and other transducers that would be used by the Navy as part of MITT, and impulsive sound sources such as air guns and impact pile driving that would not be used by the Navy as part of MITT. Recent studies have begun to show that some cetaceans may learn to reduce their hearing sensitivity (presumably to protect their hearing)

when warned of an impending intense sound exposure (Finneran 2018; Nachtigall and Supin 2013; Nachtigall and Supin 2014; Nachtigall et al. 2016; Nachtigall et al. 2017). The marine mammal criteria and thresholds for hearing impairment and non-auditory injury from sonars and other transducers used for the Navy's quantitative model were described in Section 2.2.3.

Physiological Stress

The growing field of conservation physiology relies in part on the ability to monitor stress hormones in populations of animals, particularly those that are threatened or endangered. The ability to make predictions from stress hormones about impacts to individuals and populations exposed to various forms of stressors, natural and human-caused, relies on understanding the linkages between changes in stress hormones and resulting physiological impacts. At this time, the sound characteristics that correlate with specific stress responses in cetaceans are poorly understood, as are the ultimate consequences due to these changes. Efforts are underway to try to improve understanding of, and the ability to predict, how stressors ultimately affect cetacean populations (e.g., New et al. 2013a; New et al. 2013b; Pirotta et al. 2015). With respect to acoustically-induced stress, this includes not only determining how and to what degree various types of anthropogenic sounds cause stress in cetaceans, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the cetacean's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether they are naïve or experienced with the sound (e.g., prior experience with a stressor may result in a reduced response due to habituation; Finneran and Branstetter 2013; St Aubin and Dierauf 2001). Because there are many unknowns regarding the occurrence of acoustically-induced stress responses in cetaceans, it is a reasonable assumption that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Cetaceans naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to disease and naturally occurring toxins, lack of prey availability, and interactions with predators all contribute to the stress a cetacean experiences (Atkinson et al. 2015). Breeding cycles, periods of fasting, social interactions with members of the same species are also stressors, although they are natural components of an animal's life history. Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally (Fair et al. 2014; Meissner et al. 2015; Rolland et al. 2012). Anthropogenic stressors potentially include such things as fishery interactions, pollution, and ocean noise.

The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor (Moberg 2000). 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.

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., Romero and Wikelski 2001; Sapolsky et al. 2000). If the magnitude and duration of the stress response is too great, too long, or occurs at a time when the animal is in a vulnerable state, it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction).

What is known about the function of the various stress hormones is based largely upon observations of the stress response in terrestrial mammals. The endocrine response of marine mammals to stress may not be the same as that of terrestrial mammals because of the selective pressures marine mammals faced during their evolution in an ocean environment (Atkinson et al. 2015). For example, due to the necessity of breath-holding while diving and foraging at depth, the physiological role of the epinephrine and norepinephrine (the catecholamines) may be different in marine versus terrestrial mammals. Catecholamines increase during breath-hold diving in seals, co-occurring with a reduction in heart rate, peripheral vasoconstriction (constriction of blood vessels), and an increased reliance on anaerobic metabolism during extended dives (Hance et al. 1982; Hochachka et al. 1995; Hurford et al. 1996). The catecholamine increase is not associated with an increased heart rate, glycemic release, and increased oxygen consumption typical of terrestrial mammals. Other hormone functions may also be different, such as aldosterone, which has been speculated to not only contribute to electrolyte balance, but possibly also the maintenance of blood pressure during periods of vasoconstriction (Houser et al. 2011). In marine mammals, aldosterone is thought to play a particular role in stress mediation because of its noted role in mitigating stress response (St Aubin and Dierauf 2001; St. Aubin and Geraci 1989).

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in cetaceans, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al. 1990) but showed a small but statistically significant increase in catecholamines following exposure to impulsive sounds produced from a

seismic water gun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate a statistically significant elevation in aldosterone (Romano et al. 2004), albeit the increase was within the normal daily variation observed in this species (St. Aubin et al. 1996). Increases in heart rate were observed in bottlenose dolphins to which known calls of other dolphins were played, although no increase in heart rate was observed when background tank noise was played back (Miksis et al. 2001). Unfortunately, it cannot be determined from this study whether the increase in heart rate was due to stress or an anticipation of being reunited with the dolphin to which the vocalization belonged. Similarly, a young beluga's heart rate was observed to increase during exposure to noise, with increases dependent upon the frequency band of noise and duration of exposure, and with a sharp decrease to normal or below normal levels upon cessation of the exposure (Lyamin et al. 2011). However, this response may have been in part due to the conditions during testing. Kvadsheim et al. (2010) measured the heart rate of captive hooded seals during exposure to sonar signals, and found an increase in the heart rate of the seals during exposure periods versus control periods when the animals were at the surface. When the animals dove, the normal dive-related bradycardia (decrease in heart rate) was not impacted by the sonar exposure. Similarly, Thompson et al. (1998; cited in Gordon et al., 2003) observed a rapid but short-lived decrease in heart rates in harbor and gray seals exposed to seismic air guns. Williams et al. (2017) found a non-linear increase in oxygen consumption with both stroke rate and heart rate in swimming and diving bottlenose dolphins, and found that the average energy expended per stroke increased from 2.81 Joules/kilogram/stroke during preferred swim speeds to a maximum expenditure of 6.41 Joules/kilogram/stroke when freely following a boat.

Similarly, a limited amount of work has addressed how chronic exposure to acoustic stressors affect stress hormones in cetaceans, particularly as it relates to survival or reproduction. 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, 2001, shipping was significantly reduced in the region where fecal collections were made, and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al. 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (e.g., Bain 2002; Erbe 2002b; Noren et al. 2009). Most of these efforts focused primarily on estimates of metabolic costs associated with altered behavior or inferred consequences of boat presence and noise, but did not directly measure stress hormones. However, Ayres et al. (2012) investigated Southern Resident killer whale fecal thyroid hormone and cortisol metabolites to assess two potential threats to the species recovery: lack of prey (salmon) and impacts from exposure to the physical presence of vessel traffic (but without measuring vessel traffic noise). Ayres et al. (2012) concluded from these stress hormone measurements that the lack of prey overshadowed any population-level physiological impacts on southern resident killer whales due to vessel traffic. Collectively, these studies indicate the difficulty in teasing out factors that are dominant in exerting influence on the secretion of stress hormones, including the separate and additive effects of vessel presence and vessel noise.

Masking

Clark et al. (2009) developed a method for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that a right whale's optimal communication space (around 20 km) is decreased by 84 percent when two commercial ships pass through it. Similarly, Aguilar Soto et al. (2006) found that a 15 dB increase in background noise due to vessels led to a communication range of only 18 percent of its normal value for foraging beaked whales. Their method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions such as pre-industrial ambient noise conditions and simplifications of animal hearing and behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Erbe (2015); (Erbe et al. 2016) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, and noise-source location, distance relative to each other, and received level of the call.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by cetaceans, such as whistling, echolocation click production, calling, and singing. Vocalization changes may result from a need to compete with an increase in background noise and include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkin and Parks 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (e.g., Holt 2008; Holt et al. 2011; Rolland et al. 2012) as well as changes in the natural acoustic environment (Dunlop et al. 2014). Vocal changes can be temporary, or can be permanent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen and Parks 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). In some cases, these vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al. 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may also move beyond vocal modifications (Dunlop et al. 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a different location to improve binaural cues (time or intensity differences between the ears due to a sound source's location relative to the animal's head), or going still to reduce noise associated with hydrodynamic flow. The structure of some noises (e.g., amplitude modulation) may also provide

some release from masking through comodulation masking release (the difference in masking when a noise is broadband versus having the same bandwidth as the signal; Branstetter and Finneran 2008). Signal characteristics (e.g., whether the signal has harmonics, or is frequency modulated) may further enhance the detectability of a signal in noise (Cunningham et al. 2014).

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators (Allen et al. 2014; Cummings and Thompson 1971a; Cure et al. 2015), which may be reduced in the presence of a masking noise, particularly if it occurs in the same frequency band. Therefore, the occurrence of masking may prevent marine mammals from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking and the likelihood of encountering a predator during the time that detection and identification of predator cues are impeded. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required to attend to all killer whale calls. Similarly, sperm whales (Isojunno et al. 2016), long-finned pilot whales (Visser et al. 2016), and humpback whales (Curé et al., 2015) changed their behavior in response to killer whale vocalization playbacks. These findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking could occur as a result of sonar and other transducers. As stated previously, masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Because traditional military sonars typically have low duty cycles, the effects of such masking would likely be limited when compared with continuous sources (e.g., vessel noise). Low-frequency active sonar could overlap with mysticete vocalizations (e.g., minke and humpback whales). For example, in the presence of low-frequency active sonar, humpback whales were observed to increase the length of their songs (Fristrup et al. 2003; Miller et al. 2000), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar.

Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for mid-frequency cetaceans. The Navy has proposed to conduct 616 hours of high duty cycle variable depth sonar (MF12) and 50 hours of mid-frequency sonobuoys with high duty cycles (ASW5) annually as part of the proposed action. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high frequency acoustic sources such as pingers that operate at higher repetition rates (e.g., two to ten kHz with harmonics up to 19 kHz, 76 to 77 pings per minute (Culik et al. 2001) also operate at lower source levels. While the lower source levels of these systems limits the range of impact compared to more traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high duty cycle systems operate overlaps the vocalization frequency of a number of mid-frequency cetaceans (e.g., ESA-listed

sperm whales). Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically-mediated cooperative behaviors such as foraging or reproductive activities. With mid-frequency high duty cycle systems, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g. killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high duty cycle sonars on cetaceans, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g. vessel noise and low-frequency cetaceans), and will likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm and Slabbekoorn 2005; Hotchkin and Parks 2013) and behavioral impacts such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al. 2003a; Sivle et al. 2016). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al. 2004; Parks et al. 2007), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm and Slabbekoorn 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm and Slabbekoorn 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al. 2003a).

Behavioral Reactions

Acoustic stimuli in the marine environment can cause a behavioral response in cetaceans and can also influence how or if a cetacean responds to a sound such as the presence of predators, prey, or conspecifics. The response of a cetacean to anthropogenic sound may depend on the frequency, duration, temporal pattern and amplitude of the sound, as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al. 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).

A review of cetacean responses to anthropogenic sound was first conducted by Richardson et al. (1995b). Other reviews (Gomez et al. 2016; Nowacek et al. 2007; Southall et al. 2007) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed cetacean was known or could be estimated, and also examined the role of context. Southall et al. (2007) synthesized data from many behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. Southall et al. (2016) reviewed the range of experimental field studies that have been conducted to measure behavioral responses of cetaceans to sonar. While, in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007; Southall et al. 2016). Ellison et al. (2012) outlined an approach to assessing the effects of sound on cetaceans that incorporates these contextual-based factors. They

recommend considering not just the received level of sound, but also what activity the animal is engaged in, the nature and novelty of the sound (i.e., is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context" as described, greatly influences the type of behavioral response exhibited by the animal. Forney et al. (2017) also note that an apparent lack of response (e.g. no displacement or avoidance of a sound source) may not necessarily mean there is no cost to the individual or population, as some resources or habitats may be of such high value that animals may choose to stay, even when experiencing stress or hearing loss. Forney et al. (2017) recommend considering both the costs of remaining in an area of noise exposure such as TTS, PTS or masking, which could lead to an increased risk of predation or other threats or a decreased capability to forage, and the costs of displacement, including potential increased risk of vessel strike or bycatch, increased risks of predation or competition for resources, or decreased habitat suitability for foraging, resting, or socializing.

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 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. For most cetacean species, little or no data exist on behavioral responses to any sound source, and so all species have been grouped into broad taxonomic groups from which general response information can be inferred.

Cetacean behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, U.S. (e.g., off Southern California, Hawaii, and the east coast), Mediterranean, Australian, and Norwegian waters. These studies have attempted to define and measure responses of cetaceans to controlled exposures of sonar and other sounds to understand their potential impacts better. While controlling for as many variables as possible (e.g., the distance and movement of the source), these studies also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation. In addition, distances of the sound source from the whales during behavioral response studies were always within 1 to 8 km. Some of these studies have suggested that ramping-up a source from a lower source level would act as a protective measure to mitigate higher order (e.g., TTS or PTS) impacts of sonar. However, this practice may only be effective for more responsive animals, and for short durations (e.g., 5 min.) of ramp-up (von Benda-Beckmann et al. 2016; von Benda-Beckmann et

al. 2014; Wensveen et al. 2017). Therefore, while these studies have provided the most information to date on behavioral responses of cetaceans to sonar, there are still many contextual factors to be teased apart and determining what might produce a significant behavioral response is currently difficult to discern.

Passive acoustic monitoring and visual observational behavioral response studies have also been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Deakos and Richlen 2015; Henderson et al. 2016; Manzano-Roth et al. 2016; Martin et al. 2015; Mccarthy et al. 2011; Mobley and Deakos 2015; Moretti et al. 2014; Tyack et al. 2011b). In addition, extensive aerial, visual, and acoustic monitoring is conducted before, during and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Campbell et al. 2010; Farak et al. 2011; HDR 2011b; Navy 2011b; Navy 2013a; Navy 2014b; Navy 2015b; Norris et al. 2012b; Smultea and Mobley 2009; Smultea et al. 2009; Trickey et al. 2015). When visual and passive acoustic data collected during a training event are combined with ship movements and sonar use they provide a unique and realistic scenario for analysis. During all of these monitoring efforts, only a few behavioral responses were observed, (discussed below in *Mysticetes and Odontocetes – Behavioral Response*) and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed but typically before the event or appeared to have been deceased prior to the event (Smultea et al. 2011). It should be noted that passive acoustic studies are limited to observations of vocally-active cetaceans and visual studies are limited to what can be observed at the surface.

Harris and Thomas (2015) highlighted additional research approaches that may provide further information on behavioral responses to sonars and other transducers, beyond behavioral response type studies or passive acoustic monitoring, including conducting controlled exposures on captive animals with scaled sources (smaller sized and deployed at closer proximity) and on wild animals with both scaled and real but directed sources. Captive studies on odontocete species can provide insight into how these animals may respond in the wild (see *Odontocetes – Behavioral Response* below for details). The captive studies typically represent a more controlled approach, which allow researchers to better estimate the direct impact of the received level of sound leading to behavioral responses, and to potentially link behavioral to physiological responses. However, there are still contextual factors that must be acknowledged, including previous training to complete tasks and the presence of food rewards upon completion. There are no corresponding captive studies on mysticete whales, therefore some of the responses to higher level exposures must be extrapolated from odontocetes.

Mysticetes – Behavioral Response

The responses of mysticetes to sonar and other duty-cycled tonal sounds are highly dependent upon the characteristics of the signal, the behavioral state of the animal, the particular sensitivity and previous experience of an individual, and other contextual factors including distance of the

source, movement of the source, and the physical presence of vessels in addition to the sonar (Goldbogen et al. 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 μPa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior (DeRuiter et al. 2017; Goldbogen et al. 2013). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. In fact, when the prey field was mapped and used as a covariate in similar models looking for a response in blue whales, the response in deep-feeding behavior by blue whales was even more apparent, reinforcing the need for contextual variables to be included when assessing behavioral responses (Friedlaender et al. 2016; Southall et al. 2019)). However, even when responses did occur, the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al. 2013). Additionally, a behavioral response study by (Harris et al. 2019a) looked at the exposure of lunge feeding rates blue, fin, and humpback whales to simulated naval sonar. Results of their study showed that regardless of exposure levels, blue and fin whale lunge rates remained similar to baseline. Their study did demonstrate that humpback whales – which were exposed to the highest sound levels of controlled exposures of simulated sonar – did show a greater degree of feeding disruption than either of the other two species, both during and up to 15 minutes after sonar exposure. In another study, humpback whales exposed to a three kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al. 2014). Five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives. In this case, the alarm was comprised of a mixture of signals with frequencies from 500 to 4500 Hz, was long in duration (lasting several minutes), and was purposely designed to elicit a reaction from the animals as a prospective means of protecting them from ship strikes (Nowacek et al. 2004). Although the animals' received SPL was similar in the latter two studies (133–150 dB re 1 μPa), the frequency, duration, and temporal pattern of signal presentation were different.

Humpback whales in another behavioral response experiment in Australia also responded to a two kHz tone stimulus by changing their course during migration to move more offshore and surfacing more frequently (Dunlop et al. 2013). Humpback whales in a Norwegian behavioral response study may have habituated slightly between the first and second sonar exposure (Sivle et al. 2015), and actually responded more severely to killer whale vocalization playbacks than they did to the sonar playbacks. Several humpback whales have been observed during aerial or

visual surveys during Navy training events involving sonar (Harris et al. 2019a; Henderson et al. 2019a; Sivle et al. 2016; Wensveen et al. 2017). No avoidance or other behavioral responses were ever noted, even when the whales were observed within 5 km of a vessel with active (or possibly active) sonar and maximum received levels were estimated to be between 135 and 161 dB re 1 μPa (e.g., Mobley 2011; Mobley and Pacini 2012; Smultea et al. 2009). One group of humpback whales approached a vessel with active sonar so closely that the sonar was shut-down and the vessel slowed. The animals continued approaching and swam under the bow of the vessel (Navy 2011a). Another group of humpback whales continued heading towards a vessel with active sonar as the vessel was moving away for almost 30 minutes, with an estimated median received level of 143 dB re 1 μPa. This group was observed producing surface active behaviors such as pectoral fin slaps, tail slaps and breaches; these are very common behaviors in competitive pods during the breeding season and were not considered to have occurred in response to the sonar (Mobley et al. 2012).

The lack of response to MFAS by humpbacks (males) on breeding grounds may be tied to breeding itself. Male humpback whale testes size (Chittleborough 1955) and testosterone levels (Vu et al. 2015) have both been shown to increase during the breeding season. Therefore, it may be that humpback whale behavior is strongly driven by intrinsic factors such as hormones, while humpback whale behavior on the feeding grounds is driven by extrinsic factor such as noise (Henderson et al. 2019b).

Recently, humpback whale reaction to MFAS was reported from the Pacific Missile Range Facility on Niihau, Hawaii. During February 2018, six satellite tags were deployed on humpback whales prior to the Submarine Commanders Course, and five of the six whales (all assumed males) were exposed to MFAS during the event (Henderson et al. 2019b; Martin et al. 2019a) . Four of the five tagged whales showed some bouts of extreme movements (e.g., rapid bursts and high turning angles), only one statistically significant change in behavior was observed relative to MFAS. At the onset of MFAS (max received level of 158 dB re 1μPa), a tagged whale traveling north onto the range changed direction and began traveling south, while executing a series of steep dives of increasing depths. Received levels estimated at the bottom of each dive indicated that levels were lower during these deeper dives, possibly in an attempt to reduce received levels while moving away from the source. Once MFAS stopped, dive behavior returned to normal and the whale returned to its original northbound travel (Martin et al. 2019a) (Henderson et al. 2019b).

Few studies have tagged female humpback whales with calves. Sivle et al. (2015) conducted a series of sonar exposure experiments on the feeding grounds in the Arctic Atlantic Ocean near Bear Island and Svalbard and off Jan Mayen during 2011, 2012, and 2013. One exposure experiment included a humpback mother/calf pair with the mother as the tagged animal. The calf was not tagged, but both were seen in close association throughout the trial. Avoidance response by the mother started almost immediately after the first sonar pulse and continued until

termination of the sonar exposure. The whale was shown to change its dive profile and made one deep dive to 100 m that started within 2.5 minutes after sonar exposure.

The animal conducted shallow feeding dives to 10 to 40 m depth with frequent lunges almost continuously for a period of seven hrs before the sonar exposure, but ceased feeding a few minutes into the sonar exposure and did not resume for approximately an hour after exposure. The mother-calf pair exposed here were already on the feeding grounds (age of calf unknown) and are assumed to have already made the migration from the calving grounds (if young-of-year) and the calf may be more capable of avoidance behavior than a newly born calf on the breeding grounds.

The strongest baleen whale response in any behavioral response study was observed in a minke whale in the Sea Mammals and Sonar Safety Phase 2 study, which responded at 146 dB re 1 μPa by strongly avoiding the sound source (Harris et al. 2019b; Kvadsheim et al. 2017; Sivle et al. 2015). Although the minke whale increased its swim speed, directional movement and respiration rate, none of these were greater than rates observed in baseline behavior, and its dive behavior remained similar to baseline dives. A minke whale tagged in a Southern California behavioral response study also responded by increasing its directional movement, but maintained its speed and dive patterns, so did not demonstrate as strong of a response (Kvadsheim et al. 2017). In addition, the minke whale demonstrated some of the same avoidance behavior during the controlled ship approach with no sonar, indicating at least some of the response was to the vessel (Kvadsheim et al. 2017). Martin et al. (2015) found that the density of calling minke whales was reduced during periods of Navy training involving sonar relative to the periods before training, and increased again in the days after training was completed. The responses of individual whales could not be assessed, so in this case it is unknown whether the decrease in calling animals indicated that the animals left the range, or simply ceased calling. Similarly, minke whale detections made using Marine Acoustic Recording Instruments off Jacksonville, Florida were reduced or ceased altogether during periods of sonar use (Navy 2013c; Norris et al. 2012b) especially with an increased ping rate (Charif et al. 2015). Two minke whales also stranded in shallow water after the Navy training event in the Bahamas in 2000, although these animals were successfully returned to deep water with no physical examinations. Because there were no physical examinations of these animals, no final conclusions were drawn on whether the sonar led to their stranding (Commerce 2001; Filadelfo et al. 2009a; Filadelfo et al. 2009b).

Baleen whales have also been exposed to lower frequency sonars, with the hypothesis that these whales may react more strongly to lower frequency sounds that overlap with their vocalization range. One series of studies was undertaken in 1997 to 1998 pursuant to the Navy's Low-Frequency Sound Scientific Research Program. The frequency bands of the low-frequency sonars used were between 100 and 500 Hz, with received levels between 115 and 150 dB re 1 μPa, and the source was always stationary. Fin and blue whales were targeted on foraging grounds, singing humpback whales were exposed on breeding grounds, and gray whales were exposed during migratory behavior. These studies found only short-term responses to low-

frequency sound by some fin and humpback whales, including changes in vocal activity and avoidance of the source vessel, while other fin, humpback, and blue whales did not respond at all. When the source was in the path of migrating gray whales, they changed course up to 2 km to avoid the sound, but when the source was outside their path, little response was observed (Clark and Fristrup 2001; Croll et al. 2001; Fristrup et al. 2003; Miller et al. 2000; Nowacek et al. 2007). Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were also not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000).

Opportunistic passive acoustic based studies have also detected behavioral responses to sonar. Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low-frequency calls usually associated with feeding behavior, beginning at received levels of 110 to 120 dB re 1 μPa (Melcon et al. 2012). In another example, Risch et al. (2012); (Risch et al. 2014) concluded that reductions in humpback whale songs in the Stellwagen Bank National Marine Sanctuary were a result of an Ocean Acoustic Waveguide Remote Sensing experiment occurring about 200 km away from the whales location. However, Gong et al. (2014) analyzed the same data set while also looking at the presence of herring in the region, and found that the singing humpbacks were actually located on nearby Georges Bank and not on Stellwagen, and that the song rate in their data did not change in response to the Ocean Acoustic Waveguide Remote Sensing experiment, but could be explained by natural causes.

Although some strong responses have been observed in mysticetes to sonar and other active acoustic sources (e.g., the single minke whale), for the most part mysticete responses appear to be fairly moderate across all received levels. While some responses such as cessation of foraging or changes in dive behavior could carry short-term impacts, in all cases behavior returned to normal after the signal stopped. Mysticete responses also seem to be highly mediated by behavioral state, with no responses occurring in some behavioral states, and contextual factors and signal characteristics having more impact than received level alone. Many of the contextual factors resulting from the behavioral response studies (e.g., close approaches by multiple vessels or tagging) would not likely occur during real Navy testing and training scenarios. While there is a lack of data on behavioral responses of mysticetes to continuously active sonars, these species are known to be able to habituate to novel and continuous sounds (Nowacek et al. 2004), suggesting that they could have similar responses to high duty cycle sonars. No significant behavioral responses such as panic or stranding have been observed during monitoring of actual training exercises (Navy 2011b; Navy 2014a; Smultea et al. 2009; Watwood et al. 2012).

Odontocetes – Behavioral Response

Behavioral response studies have been conducted on odontocete species since 2007, with a focus on beaked whale (not ESA-listed) responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge and Durban 2009; Claridge et al. 2009; Martin et al. 2015; Mccarthy et al. 2011; Moretti et al. 2009; Southall et al. 2013;

Southall et al. 2012; Southall et al. 2014; Wensveen et al. 2019). Though below we will discuss results of behavioral response studies on many odontocete species (e.g., beaked whales), sperm whales are the only odontocete in the action area listed under the ESA. Results to date suggest that sperm whales are not as sensitive to anthropogenic sound sources as some other odontocetes, such as beaked whales (Southall et al. 2009). 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 (Isojunno et al. 2016; Miller et al. 2009; Miller et al. 2012; Sivle et al. 2012).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, and other unusual dive behavior (Boyd et al. 2008; Cholewiak et al. 2017; Deruiter et al. 2013a; Joyce et al. 2019; Miller et al. 2015; Southall et al. 2019; Stimpert et al. 2014; Tyack et al. 2011a). Falcone et al. (2017) modeled deep and shallow dive durations, surface interval durations, and inter-deep dive intervals of Cuvier's beaked whales against predictor values that included helicopter-dipping; mid-power mid-frequency active sonar; and hull-mounted, high-power mid-frequency active sonar along with other, non-mid-frequency active sonar predictors. They found both shallow and deep dive durations to increase as the proximity to both mid- and high-powered sources decreased, and found surface intervals and inter-deep dive intervals to also increase in the presence of both types of sonars, although surface intervals shortened during periods of no mid-frequency active sonar. The responses to the mid-power mid-frequency active sonar at closer ranges were comparable to the responses to the higher source level ship sonar, again highlighting the importance of proximity. This study also supports context as a response factor as helicopter-dipping sonars, which are shorter duration and randomly located, are more difficult for beaked whales to predict or track and therefore potentially more likely to cause a response, especially when they occur at closer distances (6 to 25 km in this study).

A response was observed in a northern bottlenose whale, which conducted the longest and deepest dive on record for that species after the sonar exposure and continued swimming away from the source for over seven hours (Miller et al. 2015). Responses occurred at received levels between 95 and 150 dB re 1 μPa. All of these exposures occurred within 1 to 8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few kilometers to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to real Navy sonar located over 100 km away, and the authors did not detect similar responses at comparable received levels. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84 to 144 and 78 to 106 dB re 1 μPa, respectively, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor in the responses to the simulated sonars (Deruiter et al. 2013a). Furthermore, recent long-term tagging work has demonstrated that the longer duration dives, considered a behavioral response by Deruiter et al. (2013a), fell within

the normal range of dive durations found for eight tagged Cuvier's beaked whales on the Southern California Offshore Range (Schorr et al. 2014). However, the longer inter-deep dive intervals found by Deruiter et al. (2013a) were among the longest found by Schorr et al. (2014) and could indicate a response to sonar. In addition, Williams et al. (2017) note that in normal deep dives or during fast swim speeds, beaked whales and other cetaceans use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described in Deruiter et al. (2013a), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expended on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams et al. (2017) was higher.

On Navy ranges, Blainville's beaked whales located on the range appeared to move off-range during sonar use and returned only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; Claridge et al. 2009; Martin et al. 2015; Mccarthy et al. 2011; Moretti et al. 2009; Tyack et al. 2011a). Blainville's beaked whales remained on the Navy range to forage throughout the rest of the year (Henderson et al. 2016), and photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whales, with 40 percent having been seen in one or more prior years, with re-sightings up to seven years apart, indicating a possibly resident population on the range (Falcone and Schorr 2014; Falcone et al. 2009). These results suggest that the range areas studied represent preferred foraging habitat regardless of the effects of the noise, and that there may be no long term consequences of the sonar activity on beaked whales in these areas.

Tyack et al. (2011a) hypothesized that beaked whale responses to sonar may represent an anti-predator response. To test this idea, vocalizations of a potential predator—a killer whale—were also played back to a Blainville's beaked whale. This exposure resulted in a similar but more pronounced reaction than that elicited by sonar playback, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area (Allen et al. 2014; Tyack et al. 2011a). This anti-predator hypothesis was also tested by playing back killer whale vocalizations to pilot whales, sperm whales, and even other killer whales, to determine responses by both potential prey and conspecifics (Miller et al. 2011; Miller et al. 2012). Results varied, from no response by killer whales to an increase in group size and attraction to the source in pilot whales (Cure et al. 2012).

While there has been a focus on beaked whale responses to sonar, other species have been studied during behavioral response studies as well, including pilot whales, killer whales, and sperm whales. Responses by these species have also included horizontal avoidance, changes in

behavioral state, changes in dive behavior, and reduced breathing rate (Antunes et al. 2014; Miller et al. 2011; Miller et al. 2014b; Miller et al. 2012). Additionally, separation of a killer whale calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al. 2011). Received level thresholds at the onset of avoidance behavior were generally higher for pilot whales (mean 150 dB re 1 μPa) and sperm whales (mean 140 dB re 1 μPa) than killer whales (mean 129 dB re 1μPa) (Antunes et al. 2014; Miller et al. 2011; Miller et al. 2012). A close examination of the tag data from the Norwegian groups showed that responses seemed to be behaviorally or signal frequency mediated. For example, killer whales only changed their dive behavior when doing deep dives at the onset of one to two kHz sonar (sweeping across frequencies), but did not change their dive behavior if they were deep diving during six to seven kHz sonar (sweeping across frequencies). Nor did they change their dive behavior if they were conducting shallow dives at the onset of either type of sonar. Similarly, pilot whales and sperm whales performed normal deep dives during six to seven kHz sonar, while during one to two kHz sonar the pilot whales conducted fewer deep dives and the sperm whales performed shorter and shallower dives (Sivle et al. 2012). In addition, pilot whales were also more likely to respond to lower received levels when non-feeding than feeding during six to seven kHz sonar exposures, but were more likely to respond at higher received levels when non-feeding during one to two kHz sonar exposures. Furthermore, pilot whales exposed to a 38 kHz downward-facing echosounder did not change their dive and foraging behavior during exposure periods, although the animals' heading variance increased and fewer deep dives were conducted (Quick et al. 2017). In contrast, killer whales were more likely to respond to either sonar type when non-feeding than when feeding (Harris et al. 2015). These results again demonstrate that the behavioral state of the animal mediates the likelihood of a behavioral response, as do the characteristics (e.g., frequency) of the sound source itself.

Other responses during behavioral response studies included the synchronization of pilot whale surfacings with sonar pulses during one exposure, possibly as a means of mitigating the sound (Wensveen et al. 2015), and mimicry of the sonar with whistles by pilot whales (Alves et al. 2014), false killer whales (Deruiter et al. 2013c), and Risso's dolphins (Smultea et al. 2012). In contrast, in another study melon-headed whales had "minor transient silencing" (a brief, non-lasting period of silence) after each six to seven kHz signal, and (in a different oceanographic region) pilot whales had no apparent response (Deruiter et al. 2013b). The probability of detecting delphinid vocalizations (whistles, clicks, and buzzes) increased during periods of sonar relative to the period prior to sonar in a passive acoustic study using Marine Autonomous Recording Units in the Jacksonville Range Complex, while there was no impact of sonar to the probability of detecting sperm whale clicks (Charif et al. 2015; Navy 2013a).

In addition, killer whale sighting data from the same region in Norway as the behavioral response study was used to compare the presence or absence of whales from other years against the period with sonar. The authors found a strong relationship between the presence of whales and the abundance of herring, and only a weak relationship between the whales and sonar

activity (Kuningas et al. 2013). Baird et al. (2013) also tagged four shallow-diving odontocete species (rough toothed dolphins, pilot whales, bottlenose dolphins, and false killer whales) in Hawaii off the Pacific Missile Range Facility before Navy training exercises. None of the tagged animals demonstrated a large-scale avoidance response to the sonar as they moved on or near the range, in some cases even traveling towards areas of higher noise levels, while estimated received SPLs varied from 130 to 168 dB re 1 μPa and distances from sonar sources ranged between 3.2 to 94.4 km. However, one pilot whale did have reduced dive rates (from 2.6 dives per hour before to 1.6 dives per hour during) and deeper dives (from a mean of 124 m to 268 m) during a period of sonar exposure. Baird et al. (2016) also tagged four short-finned pilot whales from both the resident island-associated population and from the pelagic population. The core range for the pelagic population was over 20 times larger than for the pelagic population, leading the researchers to hypothesize that that likelihood of exposure to mid-frequency active sonar, and therefore the potential for response, would be very different between the two populations. These diverse examples demonstrate that responses can be varied, are often context- and behaviorally-driven, and can be species and even exposure specific.

Other opportunistic observations of behavioral responses to sonar have occurred as well, although in those cases it is difficult to attribute observed responses directly to the sonar exposure, or to know exactly what form the response took. For example, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz and up to 220 dB re 1 μPa (Bowles et al. 1994), although it could not be determined whether the animals ceased sound production or left the area. In May 2003, killer whales in Haro Strait, Washington exhibited what were believed by some observers to be aberrant behaviors, during which time the *USS Shoup* was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the *USS Shoup* transmissions (Fromm 2009; Navy 2003; NMFS 2005) estimated a mean received SPL of approximately 169 dB re 1 μPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 μPa). However, attributing the observed behaviors to any one cause is problematic given there were six nearby whale watch vessels surrounding the pod, and subsequent research has demonstrated that "Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close" (NOAA 2014c). Several odontocete species, including bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and leaving the area (at the highest received levels animals were not present in the area at all) (Henderson et al. 2014). However, these observations were conducted from a vessel off-range, and so any observed responses could not be attributed to the sonar with any certainty. Research on sperm whales in the Caribbean in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and

leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins 1985; Watkins and Schevill 1975). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

During aerial and visual monitoring of Navy training events involving sonar, rough-toothed dolphins and unidentified dolphins were observed approaching the vessel with active sonar as if to bowride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (HDR 2011b; Navy 2011a; Watwood et al. 2012). During small boat surveys near the Navy's Southern California Offshore Range in southern California, more dolphins were encountered in June compared to a similar survey conducted the previous November after seven days of mid-frequency sonar activity. It was not investigated if this change was due to the sonar activity or was a seasonal difference that could be observed in other years (Campbell et al. 2010). There were also fewer passive acoustic dolphin detections during and after longer sonar activities in the Marianas Islands Range Complex, with the post-activity absence lasting longer than the mean dolphin absence of two days when sonar was not present (Munger et al. 2014; Munger et al. 2015).

Acoustic harassment devices and acoustic deterrent devices have been used to deter cetaceans from approaching fishing gear both to prevent entanglement and to reduce depredation (taking fish). These devices have been used successfully to deter harbor porpoises and beaked whales from getting entangled in fishing nets. For example, Kyhn et al. (2015) tested two types of pingers, one with a ten kHz tone and one with a broadband 30 to 160 kHz sweep. Porpoise detection rates were reduced by 65 percent for the sweep and 40 percent for the tone and, while there was some gradual habituation after the first two to four exposures, longer term exposures (over 28 days) showed no evidence of additional habituation. (Kindt-Larsen et al. 2018) also report on the effectiveness of pingers to deter harbor porpoise from depredating fishing nets and also indicate no evidence of habituation. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975). Acoustic harassment devices used to deter cetaceans from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 μPa on a longline to prevent depredation by killer whales, and although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of cetacean deterrents, Schakner and Blumstein (2013) point out that both the characteristics of deterrents and the motivation of the animal play a role in the effectiveness of acoustic harassment devices. Deterrents that are strongly aversive either simulate a predator or are otherwise predictive of a threat are those more likely to be effective, unless the animal habituates to the signal or learns that there is no true threat associated with the signal. In some cases the net pingers may create a "dinner bell effect," where cetaceans have learned to associate

the signal with the availability of prey (Jefferson and Curry 1996; Schakner and Blumstein 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales because these species are not depredating from the nets but are getting entangled when foraging in the area and are unable to detect the net (Carretta and Barlow 2008; Schakner and Blumstein 2013). Additional behavioral studies have been conducted with captive harbor porpoises using acoustic alarms, such as those used on fishing nets to help deter cetaceans from becoming caught or entangled (Kastelein et al. 2001; Kastelein et al. 2006). These studies have found that high-frequency sources with varied duration, interval, and sweep characteristics can prove to be effective deterrents for harbor porpoises (Kastelein et al. 2017; van Beest et al. 2017).

Controlled experiments have also been conducted on captive animals to estimate received levels at which behavioral responses occur. In one study, bottlenose dolphin behavioral responses were recorded when exposed to three kHz sonar-like tones between 115 and 185 dB re 1 μPa (Houser et al. 2013), and in another study bottlenose dolphins and beluga whales were presented with 1-second tones up to 203 dB re 1 μPa to measure TTS (Finneran et al. 2001; Finneran et al. 2005; Finneran and Schlundt 2004; Schlundt et al. 2000). During these studies, responses included changes in respiration rate, fluke slaps, and a refusal to participate or return to the location of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002; Schlundt et al. 2000). In the behavioral response experiment, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over ten trials. In the TTS study bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa, and beluga whales did so at received levels of 180 to 196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). While animals were commonly reinforced with food during these studies, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally respond to noise sources.

Behavioral responses to a variety of sound sources have been studied in harbor porpoises, including acoustic alarms (Kastelein et al. 2001; Kastelein et al. 2006), emissions for underwater data transmission (Kastelein et al. 2005), and tones, including one to two kHz and six to seven kHz sweeps with and without harmonics (Kastelein et al. 2014d), and 25 kHz with and without sidebands (Kastelein et al. 2015a; Kastelein et al. 2015b). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the one to two kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the six to seven kHz tonal at the same level (Kastelein et al. 2014d). When measuring the same sweeps for a startle response, the 50 percent response threshold was 133 and 101 dB re 1 μPa for one to two kHz and six to seven kHz sweeps respectively when no harmonics were present, and decreased to 90 dB re 1 μPa for

one to two kHz sweeps with harmonics present (Kastelein et al. 2014d). Harbor porpoises responded to broadband signals up to 44 kHz with a slight respiration response at 117 dB re 1 μPa and an avoidance response at 139 dB re 1 μPa, but another source with a fundamental (lowest and strongest) frequency of 18 kHz didn't have an avoidance response until 151 dB re 1 μPa (Kastelein et al. 2014a). Exposure of the same acoustic pinger to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006), again highlighting the importance of understanding species' differences in the tolerance to underwater noise, although sample sizes in these studies was small so these could reflect individual differences as well.

Behavioral responses by odontocetes to sonar and other transducers appear to run the full gamut from no response at all to responses that could potentially lead to long-term consequences for individual animals (e.g., mother-calf separation). This is likely in part due to the fact that this taxonomic group is so broad and includes some of the most sensitive species (e.g., beaked whales and harbor porpoise) as well as some of the least sensitive species (e.g., bottlenose dolphins). This is also the only group for which both field behavioral response studies and captive controlled exposure experiments have been conducted, leading to the assessment of both contextually-driven responses as well as dose-based responses. This wide range in both exposure situations and individual- and species-sensitivities makes reaching general conclusions difficult. However, it does appear as though exposures in close proximity, with multiple vessels that approach the animal, lead to higher-level responses in most odontocete species regardless of received level or behavioral state. In contrast, in more "real-world" exposure situations, with distant sources moving in variable directions, behavioral responses appear to be driven by behavioral state, individual experience, or species-level sensitivities. These responses may also occur more in-line with received level such that the likelihood of a response would increase with increased received levels. However, these "real-world" responses are more likely to be short-term, lasting the duration of the exposure.

Range to Effects

Section 2.2.2 presented information on the criteria and thresholds used to estimate impacts to marine mammals from sonar and other transducers. Additional information on these criteria is described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a). This section presents information on the range to effects for different sonar sources.

The following tables provide range to effects for sonar and other active acoustic sources to these specific criteria, as they were used in NAEMO. Cetaceans within these ranges would be predicted to receive the associated effect. The ranges to the PTS threshold for an exposure of 30 seconds relative to the cetacean's functional hearing group are shown in Table 59. This period (30 seconds) was chosen based on examining the maximum amount of time a cetacean would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 m per second. The ranges provided in the table include the average range to PTS, as well as the range from the minimum to

the maximum distance at which PTS is possible for each hearing group. For a SQS-53C (i.e., bin MF1) sonar transmitting for 30 seconds at three kHz and a source level of 235 dB re 1 μPa^2-s at 1 m, the average range to PTS for the low-frequency cetaceans extends from the source to a range of 65 m. PTS ranges for all other functional hearing groups are much shorter. Since any hull-mounted sonar, such as the SQS-53C, engaged in anti-submarine warfare training would be moving at between 10 to 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m during the time between those pings (note: ten knots is the speed used in NAEMO). As a result, there is no overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other bins (besides MF1), PTS ranges are short enough that cetaceans (with a nominal swim speed of approximately 1.5 m per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

Table 59. Range to PTS for five representative sonar systems (Navy 2018b).

Hearing Group	Approximate PTS (30 seconds) Ranges (m)[1]				
	Sonar bin HF4	Sonar bin LF4	Sonar bin MF1	Sonar bin MF4	Sonar bin MF5
Low-frequency Cetacean	0 (0–0)	0 (0–0)	65 (65–65)	15 (15–15)	0 (0–0)
Mid-frequency Cetacean	1 (0–1)	0 (0–0)	16 (16–16)	3 (3–3)	0 (0–0)

[1] PTS ranges extend from the sonar or other active acoustic sound source to the indicated distance. The average range to PTS is provided as well as the range from the estimated minimum to the maximum range to PTS in parentheses. Notes: *HF= high-frequency, LF = low-frequency, MF = mid-frequency*

The tables (Table 60 through Table 64) below illustrate the range to TTS for 1, 30, 60, and 120 seconds from five representative sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, successive pings can be expected to add together, further increasing the range to onset-TTS.

Table 60. Ranges to TTS for sonar bin low frequency five (LF5) over a representative range of environments within the action area (Navy 2018b).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin LF4 (Low Frequency Sources <180 dB Source Level)			
	1 sec	30 sec	60 sec	120 sec
Low-frequency Cetacean	3 (3–3)	4 (4–4)	6 (6–6)	9 (9–9)
Mid-frequency Cetacean	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Table 61. Ranges to TTS for sonar bin mid-frequency one (MF1) over a representative range of environments within the action area (Navy 2018b).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin MF1 (e.g., SQS-53 ASW Hull Mounted Sonar)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetacean	898 (850–1,025)	898 (850–1,025)	1,271 (1,025–1,525)	1,867 (1,275–3,025)
Mid-frequency Cetacean	210 (200–210)	210 (200–210)	302 (300–310)	377 (370–390)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Note: Ranges for 1-sec and 30-sec periods are identical for Bin MF1 because this system nominally pings every 50 seconds, therefore these periods encompass only a single ping.

Table 62. Ranges to TTS for sonar bin mid-frequency four (MF4) over a representative range of environments within the action area (Navy 2018b).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin MF4 (e.g., AQS-22 ASW Dipping Sonar)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetacean	85 (85–90)	161 (160–170)	229 (220–250)	352 (330–410)
Mid-frequency Cetacean	22 (22–22)	35 (35–35)	50 (45–50)	70 (70–70)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Table 63. Ranges to TTS for sonar bin mid-frequency five (MF5) over a representative range of environments within the action area (Navy 2018b).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin MF5 (e.g., SSQ-62 ASW Sonobuoy)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetacean	1 (0–2)	2 (1–3)	4 (3–5)	7 (5–8)
Mid-frequency Cetacean	10 (7–12)	17 (12–21)	24 (17–30)	33 (25–40)

[1] Ranges *to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses*

The range to received sound levels in 6-dB steps from five representative sonar bins and the percentage of animals that may exhibit a potentially significant behavioral response[8] under each behavioral response function are shown in

Table 65 through Table 69. Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group that are therefore not included in the estimated take.

Table 65 illustrates the potentially significant behavioral response for low frequency (LF4) active sonar. Table 66 through Table 68 illustrates the potentially significant behavioral response for mid-frequency (MF1, MF4, and MF5) active sonar. Table 69 illustrates the range to a potentially significant behavioral response for high-frequency (HF4) active sonar.

Table 64. Ranges to TTS for sonar bin high frequency four (HF4) over a representative range of environments within the action area (Navy 2018b).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin HF4 (e.g., SQS-20 Mine Hunting Sonar)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetacean	1 (0–2)	2 (1–3)	4 (3–5)	7 (5–8)
Mid-frequency Cetacean	10 (7–12)	17 (12–21)	24 (17–30)	33 (25–40)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Table 65. Ranges to a potentially significant behavioral response for an example low frequency sonar bin (LF4) over a representative range of environments within the action area (Navy 2018b).

Received Level (dB re 1 μPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin LF4*	
		Odontocete	*Mysticete*
196	1 (1–1)	100%	100%
190	3 (3–3)	100%	98%
184	6 (6–6)	99%	88%
178	12 (12–12)	97%	59%
172	25 (25–25)	91%	30%
166	51 (50–55)	78%	20%
160	130 (130–160)	58%	18%

[8] See Marine Mammal Criteria for Behavioral Response within Section 2.2.2 above for detailed discussion of the term 'significant behavioral response.'

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin LF4	
		Odontocete	Mysticete
154	272 (270–300)	40%	17%
148	560 (550–675)	29%	16%
142	1,048 (1,025–1,525)	25%	13%
136	2,213 (1,525–4,525)	23%	9%
130	4,550 (2,275–24,025)	20%	5%
124	16,903 (4,025–66,275)	17%	2%
118	43,256 (7,025–87,775)	12%	1%
112	60,155 (7,775–100,000*)	6%	0%
106	80,689 (8,775–100,000*)	3%	0%
100	92,352 (9,025–100,000*)	1%	0%

** Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms
dB re 1 µPa = decibels referenced to one micropascal, LF = low-frequency

Table 66. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF1) over a representative range of environments within the action area (Navy 2018b).

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF1	
		Odontocete	Mysticete
196	106 (100–110)	100%	100%
190	240 (240–250)	100%	98%
184	501 (490–525)	99%	88%
178	1,019 (975–1,025)	97%	59%
172	3,275 (2,025–5,275)	91%	30%
166	7,506 (2,525–11,025)	78%	20%
160	15,261 (4,775–20,775)	58%	18%
154	27,759 (5,525–36,525)	40%	17%
148	43,166 (7,525–65,275)	29%	16%
142	58,781 (8,525–73,525)	25%	13%
136	71,561 (11,275–90,775)	23%	9%
130	83,711 (13,025–100,000*)	20%	5%
124	88,500 (23,525–100,000*)	17%	2%
118	90,601 (27,025–100,000*)	12%	1%
112	92,750 (27,025–100,000*)	6%	0%
106	94,469 (27,025–100,000*)	3%	0%
100	95,838 (27,025–100,000*)	1%	0%

** Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms
dB re 1 µPa = decibels referenced to one micropascal, MF = mid-frequency

Table 67. Ranges to potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF4) over a representative range of environments within the action area (Navy 2018b).

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF4	
		Odontocete	Mysticete
196	8 (8–8)	100%	100%
190	17 (17–17)	100%	98%
184	35 (35–35)	99%	88%
178	70 (65–70)	97%	59%
172	141 (140–150)	91%	30%
166	354 (330–420)	78%	20%
160	773 (725–1,275)	58%	18%
154	1,489 (1,025–3,275)	40%	17%
148	3,106 (1,775–6,775)	29%	16%
142	8,982 (3,025–18,775)	25%	13%
136	15,659 (3,775–31,025)	23%	9%
130	25,228 (4,775–65,775)	20%	5%
124	41,778 (5,525–73,275)	17%	2%
118	51,832 (6,025–89,775)	12%	1%
112	62,390 (6,025–100,000*)	6%	0%
106	69,235 (6,775–100,000*)	3%	0%
100	73,656 (7,025–100,000*)	1%	0%

** Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms
dB re 1 µPa = decibels referenced to one micropascal, MF = mid-frequency

Table 68. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF5) over a representative range of environments within the action area (Navy 2018b).

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF5	
		Odontocete	Mysticete
196	0 (0–0)	100%	100%

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF5	
		Odontocete	Mysticete
190	1 (0–3)	100%	98%
184	4 (0–7)	99%	88%
178	14 (0–15)	97%	59%
172	29 (0–30)	91%	30%
166	58 (0–60)	78%	20%
160	125 (0–150)	58%	18%
154	284 (160–525)	40%	17%
148	607 (450–1,025)	29%	16%
142	1,213 (875–4,025)	25%	13%
136	2,695 (1,275–7,025)	23%	9%
130	6,301 (2,025–12,525)	20%	5%
124	10,145 (3,025–19,525)	17%	2%
118	14,359 (3,525–27,025)	12%	1%
112	19,194 (3,525–37,275)	6%	0%
106	24,153 (4,025–48,025)	3%	0%
100	29,325 (5,025–57,775)	1%	0%

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms dB re 1 µPa = decibels referenced to one micropascal, MF = mid-frequency

.

Table 69. Ranges to a potentially significant behavioral response for an example high frequency sonar bin (i.e., HF4) over a representative range of environments within the action area (Navy 2018b).

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin HF4	
		Odontocete	Mysticete
196	1 (1–1)	100%	100%
190	3 (3–3)	100%	98%
184	6 (6–6)	99%	88%
178	12 (12–12)	97%	59%
172	25 (25–25)	91%	30%
166	51 (50–55)	78%	20%
160	130 (130–160)	58%	18%
154	272 (270–300)	40%	17%
148	560 (550–675)	29%	16%
142	1,048 (1,025–1,525)	25%	13%
136	2,213 (1,525–4,525)	23%	9%
130	4,550 (2,275–24,025)	20%	5%
124	16,903 (4,025–66,275)	17%	2%

118	43,256 (7,025–87,775)	12%	1%
112	60,155 (7,775–100,000*)	6%	0%
106	80,689 (8,775–100,000*)	3%	0%
100	92,352 (9,025–100,000*)	1%	0%

Notes: dB re 1 µPa = decibels referenced to one micropascal, HF = high-frequency
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms.

** Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.*

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms.

dB re 1 µPa = decibels referenced to one micropascal, LF = low-frequency

Exposure and Response Analysis

In this section we discuss the estimated number of exposures of ESA-listed cetaceans to sonar and other transducers that are expected to rise to the level of take under the ESA, the expected magnitude of effect from those exposures, and the likely responses of the animals exposed to those effects. The exposure estimates adopted for our analysis were produced using NAEMO.

Exposure Estimates

We considered exposure estimates from the Phase III NAEMO model (Section 2.2.1) at three output points for cetaceans:

1) Unprocessed exposure estimates: The total number of exposures of ESA-listed cetaceans (animats) to acoustic sources prior to the application of a dose-response curve or criteria. This estimate is the number of times individual animats or animals are likely to be exposed to the acoustic environment that is a result of training or testing activities, regardless of whether they are injured or respond in a way that would significantly disrupt normal behavioral patterns as a result of that exposure. In most cases, the number of animals "taken" (under the ESA) by an action would be a subset of the number of animals that are exposed to the action. In some circumstances, animals might not respond to an exposure, while other responses may be negative for an individual animal without constituting a form of "take" under the ESA. Table 70 shows the total estimated number of unprocessed exposures from acoustic and explosive stressors (i.e., estimates were not broken out between the different acoustic stressors and explosives).
2) Model-estimated exposures: The total number of exposures of ESA-listed cetaceans generated by the model and "processed" using dose-response curves for behavior and criteria for TTS and PTS (i.e. NAEMO estimated exposures before mitigation and avoidance factors are applied). Model-estimated exposures were separated into sonar/transducer exposures (this Section) and explosive exposures (see below)

3) Post-processing exposure estimates: Modeled-estimated exposures resulting in injury and mortality are further analyzed to account for mitigation proposed by the Navy to avoid or reduce impacts to cetaceans and for consideration of avoidance of multiple exposures that would be expected from individual animals once they sense the presence of Navy acoustic stressors. Consideration of avoidance and mitigation reduces some modeled instances of PTS to TTS. For details, see Section 2.2.1 (above) and the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018d).

Table 70 provides the maximum annual number of unprocessed exposures (output point #1 above) for each cetacean species considered in this opinion. The estimates include exposures from both annual and non-annual training and testing activities. Further, this estimate includes sonar/transducer and explosive exposures. In most years, the number of exposures would be less than listed below as some activities are not conducted every year but all potential acoustic exposures from sonar and explosives were included to generate conservative estimates of impacts to cetaceans. The NAEMO model output did not provide data on the sex ratio or life stage of exposures for any species.

Table 70. Unprocessed exposure estimates[1] of ESA-listed cetaceans to acoustic and explosive stressors.

Species	Unprocessed exposures			
	> 121 dB rms	> 163 dB rms	>181 dB rms	> 205 dB rms
Blue whales	34,876	4,283	735	8
Fin whales	41,782	4,850	898	11
Humpback whales – Western Pacific DPSs	213,978	17,953	2,876	46
Sei whales	5,039	423	67	1
Sperm whales	71,643	6,119	841	22

[1]Numbers shown represent the maximum annual number of unprocessed exposures for each cetacean species considered in this opinion. The estimates include exposures from both annual and non-annual training and testing activities. In most years, the number of exposures would be less than shown as some activities are not conducted every year, but all potential acoustic exposures from sonar and explosives were included to generate conservative estimates of impacts to cetaceans

Table 71 shows the post-processing cetacean take estimates (output point #3 above) by species as a result of MITT activities using sonar and other transducers conducted annually in the action area. Only the more severe impact expected are quantified in this table (i.e., instances of TTS are expected to also have an associated behavioral response but this is not reflected in the behavioral response column). The NAEMO model-estimated exposures (i.e., output point #2 above) did include seven instances of humpback whale PTS and one instance of sei whale PTS annually (Navy 2019c; Navy 2020c). After avoidance and mitigation factors were applied, all model-estimated PTS exposures were reduced to TTS. For details on how these factors are applied for

post-processing take estimates refer to Section 2.2.1 or the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018d). It should be noted that the humpback whale estimates in Table 71 do not include results from NMFS's analysis of the effects of MF1 sonar on humpback whales within the GMAs. See Table 73 below for updated estimates of humpback whale takes from sonar both within the GMAs and overall throughout the action area.

Table 71. Estimated ESA-listed cetacean impacts (i.e., PTS, TTS, or significant behavioral disruption) per year from sonar and other transducers during training and testing activities.

Species	Total Estimated Annual Impacts		
	Behavioral Response	TTS	PTS
Blue Whale	4	20	0
Fin Whale	5	20	0
Sperm Whale	192	11	0
Sei Whale	17	135	0
Humpback Whale Western Pacific DPS[1]	51	419	0

[1] Humpback whale estimates do not include results from NMFS's analysis of the effects of MF1 sonar on humpback whales within the GMAs. See Table 73 below for updated estimates of humpback whale takes from sonar both within the GMAs and overall throughout the action area.

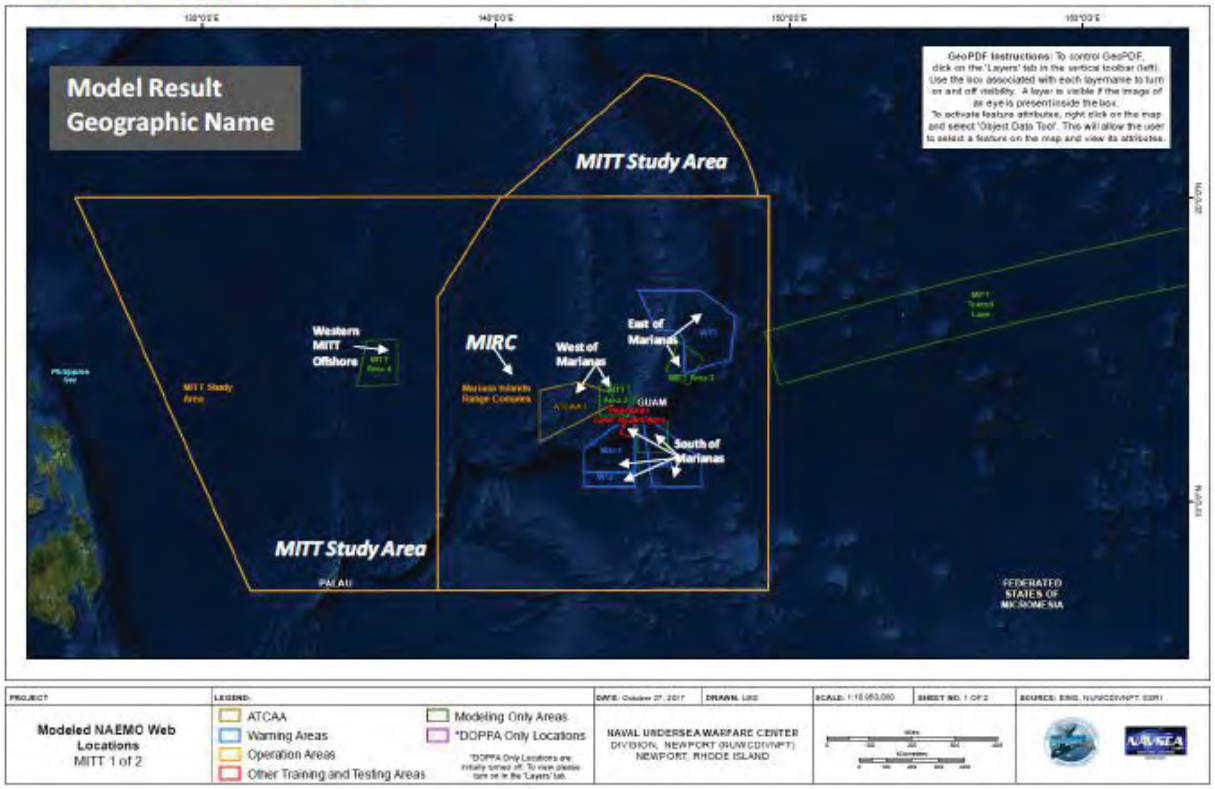


Figure 48. MITT geographic naming conventions used for NAEMO estimated impacts by region (Navy 2019e).

There is a potential for impacts to occur anywhere within the action area where sound from sonar and ESA-listed cetacean species overlap. Figure 49 through Figure 53 show the proportional distribution of the exposure estimates by region (as shown in Figure 48 above) within the action area and by activity category. Only areas and activity categories where 0.5 percent or greater of the impacts are estimated to occur are presented in these figures.

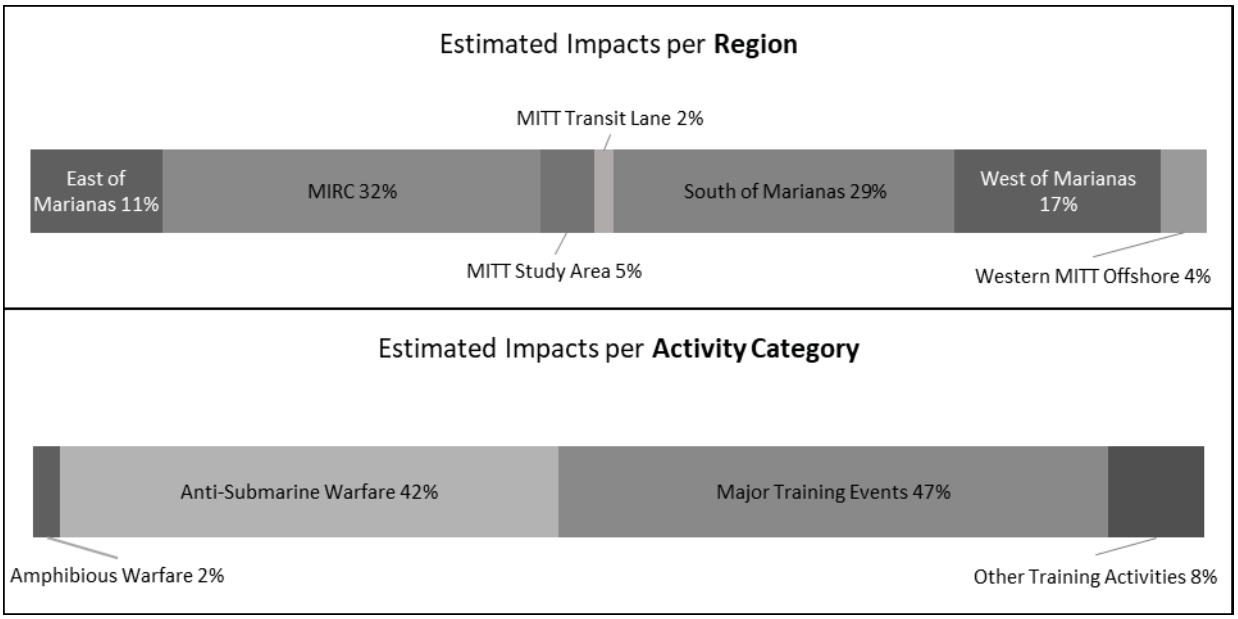


Figure 49. Blue whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action.

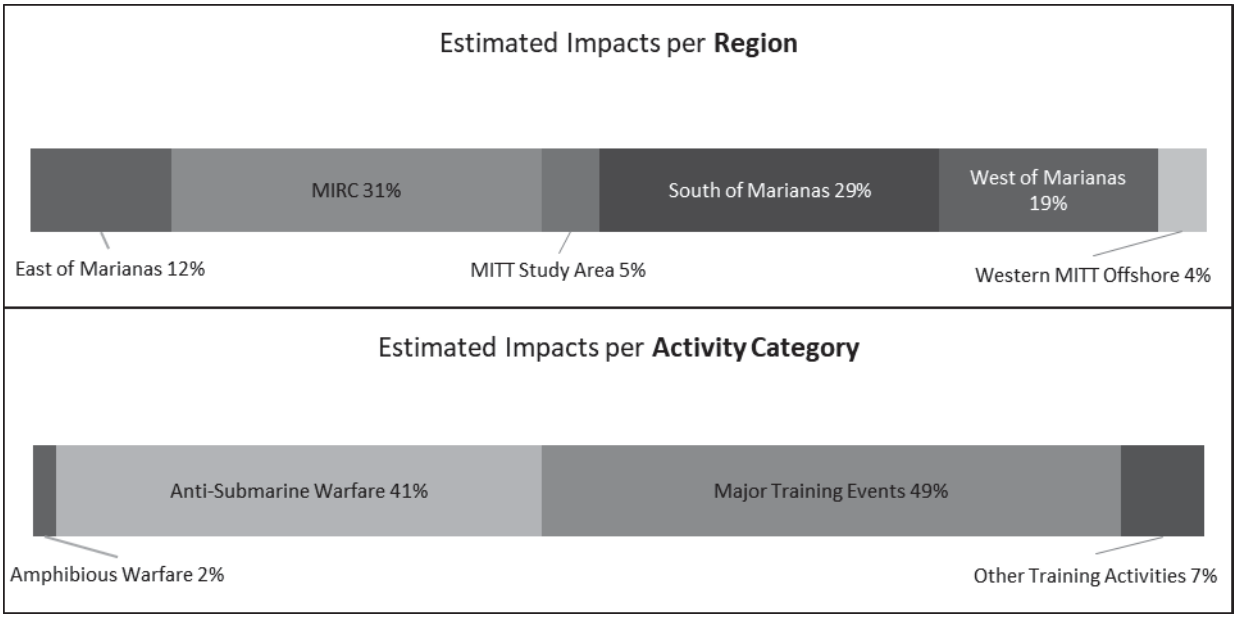


Figure 50. Fin Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action.

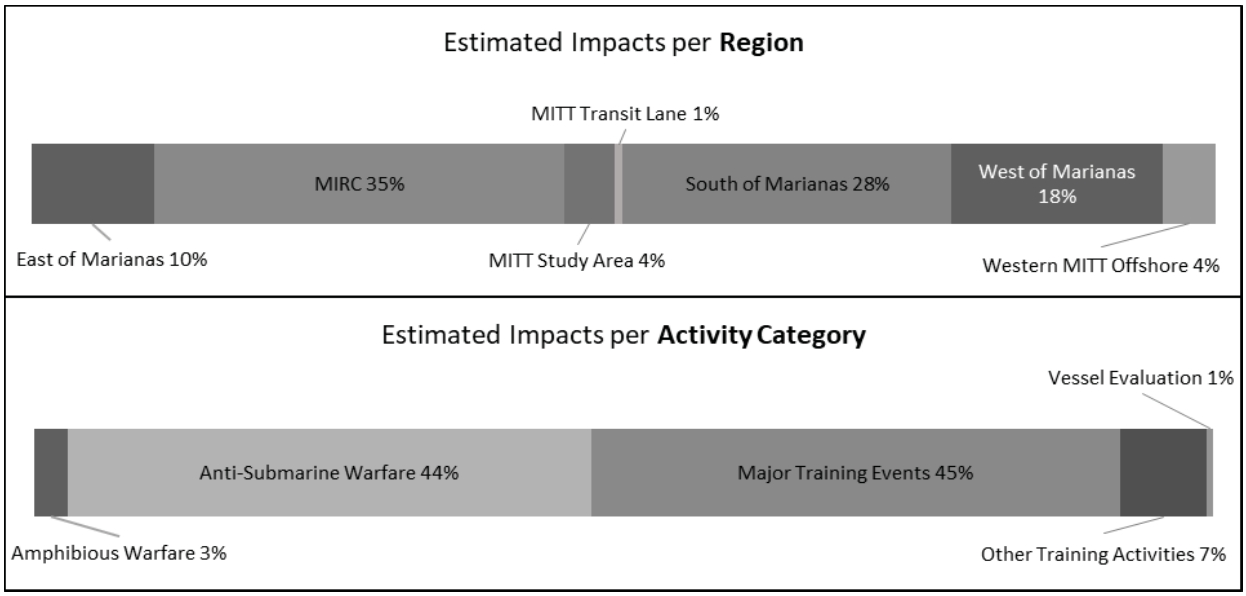


Figure 51. Humpback Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action.

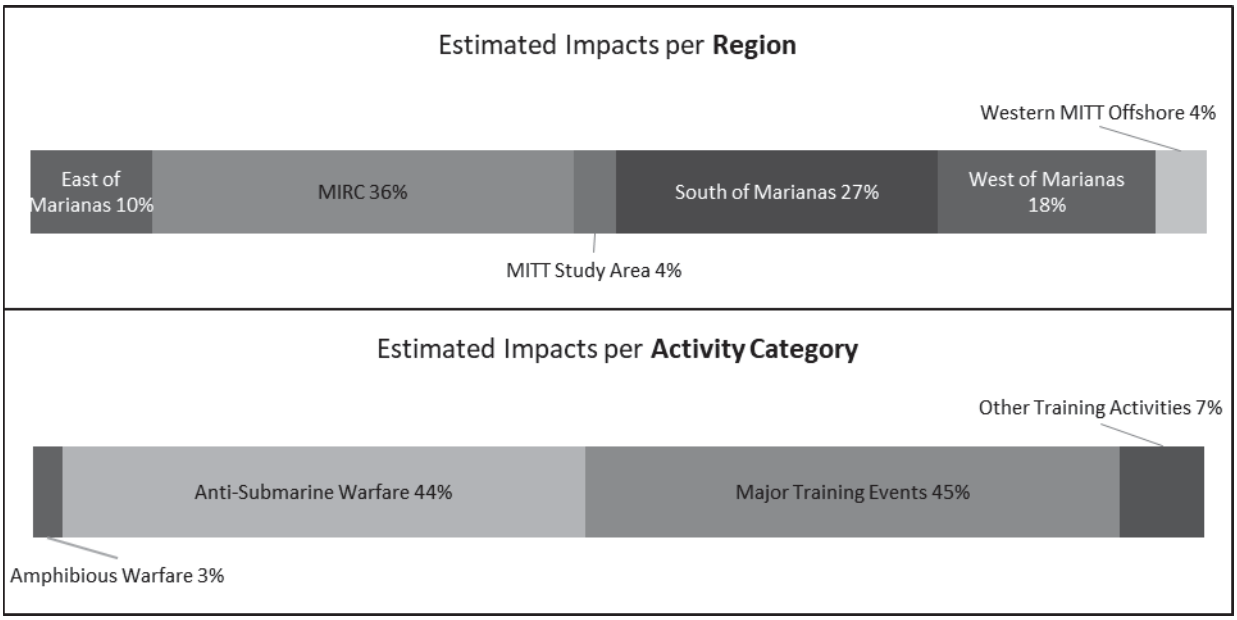


Figure 52. Sei Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action.

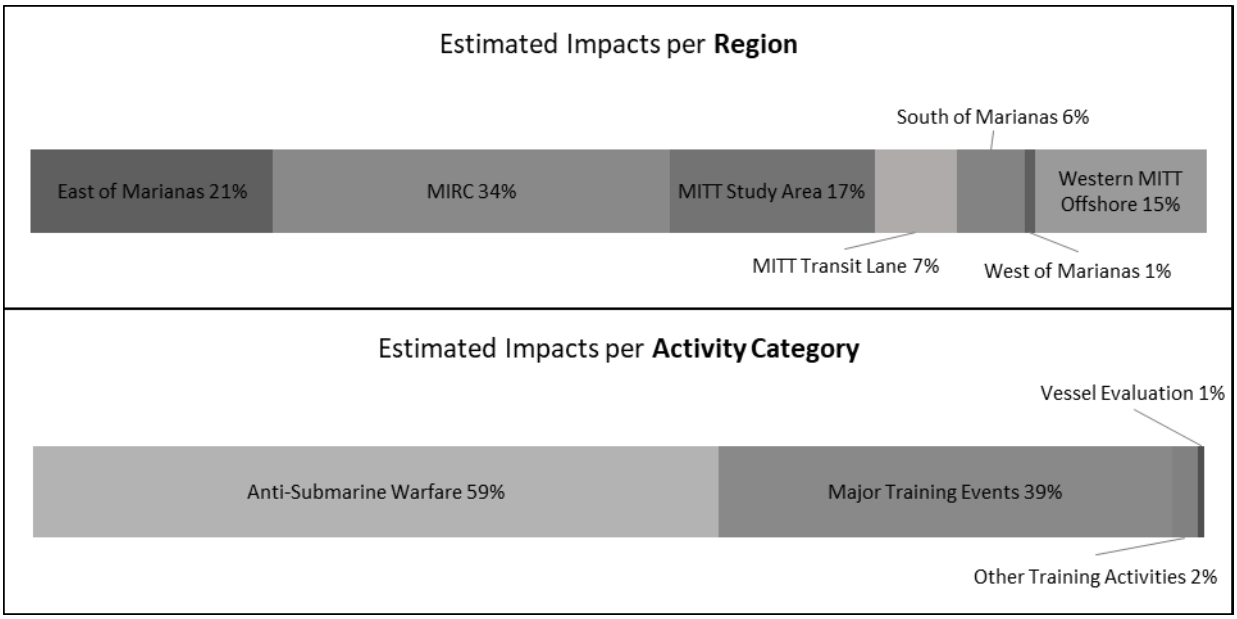


Figure 53. Sperm Whale impacts estimated per year from sonar and other transducers used during training and testing under the proposed action.

For most species and portions of the action area, we consider the post-processing exposure estimates shown in Table 71 (above) to represent the best available data on exposure of cetaceans to sonar and other transducers from the proposed action and the anticipated impacts (e.g., non-auditory injury, PTS, TTS, significant disruption of behavior), and we believe this level of exposure is reasonably certain to occur. However, based on newly available information on species density and sonar activity level, we used a different approach for analyzing the effects of sonar on humpback whales within the Chalan Kanoa and Marpi Reef GMAs. Our sonar exposure analysis for humpback whales within the GMAs is described below.

Exposure Analysis for Humpback Whales within the GMAs

The Navy's proposed action includes up to 20 hours annually of MF1 sonar within the two designated humpback whale GMAs (Chalan Kanoa Reef and Marpi Reef) combined from December-April. The 20 hours can be from TRACKEX events, a Small Joint Coordinated ASW exercise, or some combination of these two activities (Navy 2020b). As part of the Navy's proposed action, these activities would only be conducted in areas greater than three nautical miles from land.

In a Navy memo for the record dated May 15, 2020, the Navy provided new estimates of the number of humpback whale takes based on 20 hours of MF1 sonar occurring in the GMAs (outside of 3 nmi and waters greater than 60 m depth) during December through April. It should be noted that while the Navy's GMA take estimates were based on a 60 m minimum depth, the Navy's proposed action does not include a depth limitation for either the TRACKEX or Small Joint Coordinated ASW activities (only a distance from shore limitation, as noted above). The Navy's new GMA take estimates were derived from a prorating of estimated takes, based on the

contribution of takes per event type during MITT wide NAEMO modeling. The analysis assumed takes could occur in either of the two GMAs. MF1 sonar used outside of the GMAs would not be inclusive in these estimates and would be part of the overall MIRC take estimation.

The resulting take estimates provided by the Navy were 2.12 behavioral and 11.08 TTS (13.20 Level B takes in total). These take estimates represent five ASW TRACKEX events with each event using four hours of MF1 sonar; a single four-hour TRACKEX event was expected to result in 0.42 behavioral and 2.2 TTS takes (2.62 Level B takes in total). However, the approach used to calculate these take estimates did not consider the concentration of humpback whales found within these established breeding and calving grounds from December through April.

Our exposure analysis for humpback whales in the GMAs uses the best available humpback whale abundance and density information from NMFS surveys around Saipan conducted by the Pacific Islands Fisheries Science Center (PIFSC) and reported in Hill et al. (2020a) and Hill et al. (2020b). We believe this approach more accurately estimates potential exposures and takes of whales as a result of MF1 sonar in the GMAs. There are no data to suggest whales are restricted to either of the GMAs, but the vast majority (approximately 98%) of all sightings did occur within either of the two GMAs. Therefore, based on the abundance and density of whales in the region, these areas represent a biologically important area for an endangered population of humpback whales that should be considered in protection and conservation efforts (Hill et al. 2020b).

Using the Hill et al. (2020a) survey data from 2015-2018, a sightings per unit of effort (SPUE; number of animals seen per survey hour) approach to estimate the numbers of animals that may be encountered was examined by NMFS. The sighting data collected by the PIFSC showed that throughout the first four years of surveys, the daily number of animals seen ranged from 0-11 individuals per day. Sightings per unit of effort can be misleading and relies heavily on the timing of the surveys, the extent to which the survey covers an area adequately, and the timing of the migration of the whales. Based on the Hill et al. (2020a) dataset, there were 183.9 survey hours during the four years and the resulting SPUE was 0.299 animals seen per hour. The average unique encounter rate was 1.26 (39 encounters in 31 survey days) and the unique number of animals per day was 1.77 (14 mother calf pairs – 28, plus 27 non-calf whales = 55 total animals/31 survey days). While these estimates provide a potential range of values, they lack a range of variability estimates, are not statistically robust, and inadequately address the potential number of humpback whales that could occur in the GMAs. This was primarily because the average survey effort was only seven days per year (36 days over 5 years - with 2019 data included), whereas sighting information indicates that humpback whales could be present in these areas for up to five months (i.e., December through April).

In August 2019, we asked the PIFSC to calculate a density estimate of the humpback whales seen during surveys from 2015-2019 within the areas around Saipan to more accurately capture the density of animals in this region. The intention was to incorporate the new information

specific to these areas as a way to provide more accurate density estimates – and therefore exposures – of humpbacks for the shallow-water areas than what was available when the Navy ran the NAEMO analysis for the BA. In November 2019, the PIFSC provided a preliminary report, which was finalized in June 2020, with annual estimates of humpback whale abundance and density for the areas around Saipan – including the GMAs (Hill et al. 2020a). Since NMFS does not have access to the NAEMO model, we were unable to incorporate the new density information to produce updated take estimates based on the Navy's analytical approach for quantifying acoustic effects.

Instead, we used a different approach based on the annual abundance estimates from the PIFSC report (Hill et al. 2020a) to derive estimates of animals that may be exposed to MF1 sonar within the GMAs. Preliminary annual (2015–2019) estimates of abundance, including standard errors (SE), 95% confidence intervals (CI), and densities of humpback whales in the PIFSC's study area were calculated using mark-recapture analyses (Table 72). Densities (whales/km^2) are reported for the full survey area (839 km^2; Figure 54) and the truncated survey area where most of the effort and all of the humpback whale encounters occurred (384 km^2; Figure 54). The error associated with the average non-calf and total abundance was obtained by summing the variances of the annual estimates even though these estimates are not independent, as using a bootstrap or other approach to estimate uncertainty was beyond the scope of this preliminary analysis. PIFSC provided estimates of calf abundance in their annual abundance estimates by increasing the average annual abundance of whales (non-calf) by the proportion of calves seen in the four years of surveys where calves were seen (2015-2018). The proportion of calves ranges from 0.5 to 0.2. This increases the average number of animals (non-calf) from 44 to 61 (total abundance with calves; with a 95% CI of 41-91) animals. This abundance estimate includes calves and is calculated based on the five annual abundance estimates provided by the PIFSC for the larger survey area (Figure 54).

Using the average total abundance estimate of 61 animals per day, we assumed the entire 61 animals could be exposed (95% CI = 41 – 91 exposures per day) to MF1 sonar in the area. This assumes that no animal would be exposed more than once per day. The total accumulation of exposure estimates is 305 (61*5) whales that may be exposed in 20 hours of MF1 sonar (assuming five TRACKEX events, four hours each) for a maximum of 15.25 exposures per hour of sonar. Using the same proportions of these takes by type of take (i.e., behavioral vs. TTS) as estimated by NAEMO (i.e., 11 percent behavioral; 89 percent TTS) results in an estimated 37 behavioral and 268 TTS takes within the GMAs (Table 73).

Estimated takes of humpback whale calves from MF1 sonar use in the GMAs were based on information provided in (Hill et al. 2020a). Annual abundance estimates of calves range from 10-36 animals, with the average of 17 calves (out of 61 total whales) estimated per year (Table 72). Based on this proportion of calves (i.e., 17 out of 61 or 27.9 percent), we estimate about 10 behavioral harassment takes and 75 TTS takes of humpback whale calves annually within the GMAs.

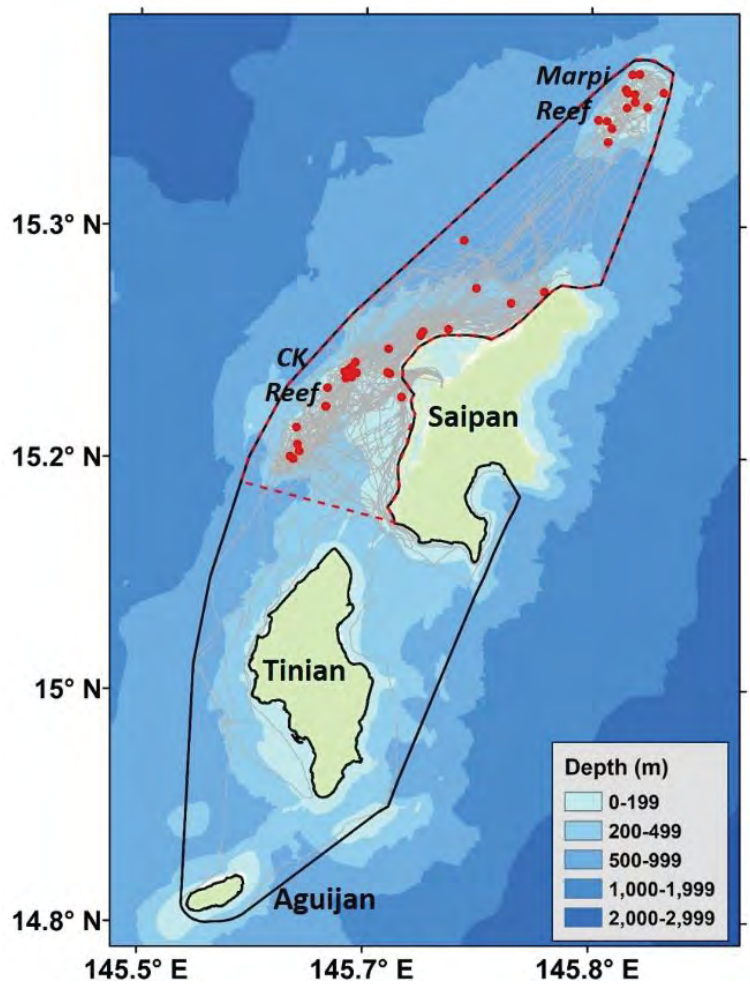


Figure 54. Pacific Islands Fisheries Science Center's (PIFSC) survey tracklines (gray lines) and humpback whale encounter locations (red dots) during winter (January–March) surveys 2015–2019. A minimum convex polygon (MCP; solid black line; 839 km2) was created to delineate the (PIFSC) survey area for estimating yearly (2015–2019) density of non-calf humpback whales within the survey area. The MCP was truncated (red dashed line; 384 km^2) to include only the areas off the west side of Saipan to Chalan Kanoa Reef (CK) and north to Marpi Reef where most of the survey effort and all of the humpback whale encounters occurred.

The total abundance estimate (with the reported range) incorporates the lower abundances of whales at the beginning and end of the migration into the area, is scaled to the entire PIFSC study area, and represents five years of surveys (each year represents a snapshot of the potential number of animals present in the area during the surveys). The mark-recapture abundance estimates used for our analysis are modeled from the actual survey data in the action area and account for the potential error associated with the average of the five years of abundance estimates. This approach is based on the best available information on humpback whale

abundance within in the GMAs, and is, therefore, more scientifically defensible than an approach that assumes an uniform abundance throughout the action area. Our exposure estimates (61 humpback whales - 44 non-calves and 17 calves) include calves and represent the maximum number of animals that could be exposed to MF1 sonar daily or in five days (305) of active sonar (four hours per day). Using the same proportions of these takes as estimated by NAEMO (i.e., 11 percent behavioral; 89 percent TTS) results in 37 behavioral and 268 TTS takes (Table 73). These estimates are conservative with regards to the species (makes the assumption that all animals are available every day to exposure to MF1 sonar) and attempts to account for the variability in the timing of whale migration from year to year and undetected whales due to survey conditions and/or potential unseen animals which may be evasive (mother/calf pairs).

Table 72. Preliminary yearly (2015–2019) estimates of abundance, including standard errors (SE) and 95% confidence intervals (CI), and densities of humpback whales in the Pacific Islands Fisheries Science Center's study area (Hill et al. 2020a).

Year	Non-calf Abundance	SE	95% CI	Total Abundance	SE	95% CI	Density Full	Density Truncated
2015	31	16	12–82	44	24	16-118	0.05	0.11
2016	26	13	10–66	36	19	14-95	0.04	0.09
2017	90	29	48–168	126	44	65-246	0.15	0.33
2018	47	19	19–99	65	27	30-143	0.08	0.17
2019	24	13	9–64	34	19	12-92	0.04	0.09
Average	44	9	30-64	61	13	41-91	0.07	0.16

As discussed above, the Navy provided a NAEMO-based estimate of 13 humpback whale takes annually resulting from 20 hours of MF1 sonar within the GMAs (Navy 2020a). The Navy also provided the following total annual humpback whale take estimates for the proposed action: 51 behavioral harassment takes; 419 TTS takes. If we subtract the Navy's estimated take of humpback whales within the GMAs (13) from our estimated take of humpback whales within the GMAs (305) we get 292 new (additional) takes from our analysis based on the new abundance information within the GMAs. Using the same proportions of these takes as estimated by NAEMO (i.e., 11 percent behavioral; 89 percent TTS) results in 35 behavioral and 257 TTS takes. We add the additional (unaccounted for) takes from our GMA analysis (35 behavioral; 257 TTS) to the Navy's updated total NAEMO estimated takes (51 behavioral; 419 TTS) to arrive at our total annual humpback whale take estimates of 86 behavioral harassment and 676 TTS takes that are reasonably certain to occur as a result of the proposed action (Table 73).

Table 73. Estimated annual humpback whale takes within the GMAs and surrounding waters of Saipan, and estimated total annual humpback whale takes (all areas) reasonably certain to occur as a result of the proposed action.

NMFS estimated annual takes within the GMAs and surrounding waters of Saipan			
Type of Take	Estimated takes (all life stages)	% of Take	Estimated calf takes
Behavioral	37	0.11	10
TTS	268	0.89	75
PTS	see discussion below		see discussion below
NMFS estimated total annual humpback whale takes (all areas)			
Takes	#s	% of Take	Estimated calf takes
Behavioral	86	0.11	10
TTS	676	0.89	75
PTS	see discussion below		see discussion below

Humpback Whale PTS Take within the GMAs

The Navy provided us with specific information about the potential for PTS exposures for humpback whales with and without the Navy's post-modeling assessment process (mitigation and avoidance) (Navy 2020c). We combined this information with our analysis of the effects of MF1 sonar on humpback whales within the GMAs (from above), to evaluate the likelihood of humpback whale PTS takes as a result of the proposed action.

The total number of unprocessed ("raw") PTS takes of humpback whales annually predicted by the NAEMO model for all events within the MITT Study area was 6.935 (Navy 2020c). The large majority of these takes (6.284) were associated with major training events (Joint Multi-Strike Exercises) (Navy 2020c). Because these events have multiple assets, platforms, and sonar sources in operation, there is a higher likelihood (as compared to a single platform event) that a whale could accumulate multiple pings of sonar that may result in PTS (Navy 2020c). Major training events would not occur in or near the GMAs due to the space and depth requirements for these activities (Navy 2020c).

The remaining 0.651 unprocessed annual PTS takes were associated with several other activities, including two activities that could occur in or near the GMAs: 1) TRACKEX - surface ship and 2) the Small Joint Coordinated ASW exercise. Based on the Navy's quantitative analysis (Navy 2020c), the number of humpback whale unprocessed PTS takes annually (December- April) within the GMAs from 20 hours of MF1 sonar is as follows: 0.002143 based on 5 TRACKEX events each lasting 4 hours; or 0.02233 based on 20 hours as part of a Small Joint Coordinated ASW event.

However, as discussed above, the Navy's estimate of humpback whale unprocessed PTS takes within the GMAs (based on NAEMO outputs) does not account for the anticipated higher abundance and density of whales within these areas from December through April, nor for the different life stages (i.e., mother-calf pairs) that would likely be exposed. From above, we estimated that 305 humpback whale takes would likely occur within the GMAs annually from

December through April as a result of 20 hours of MF1 sonar (based on 5 TRACKEX events). By comparison, the Navy's quantitative analysis estimated 13.2 takes (based on 5 TRACKEX events) within the GMAs annually from December through April. We use the ratio of our estimated number of takes within the GMAs to the Navy's estimate as a multiplier for estimating humpback whale unprocessed PTS takes: i.e., 305/13.2 = 23.11.

The Navy's quantitative analysis estimated 5.25 takes if the 20 hours of MF1 were used during a portion of a Small Joint Coordinated ASW event (instead of 5 TRACKEX events). Although our analysis did not estimate takes for a portion of a Small Joint Coordinated ASW event, we assume that the ratio of our estimate to the Navy's estimate would be the same as the ratio calculated above based on 5 TRACKEX events (i.e., 23.11).

We apply this ratio multiplier to the Navy's estimates of humpback whale unprocessed PTS takes within the GMAs as follows:

For 5 TRACKEX events: 0.002143 X 23.11 = 0.0495 unprocessed PTS takes annually

For a portion of a Small Joint Coordinated ASW event: 0.02233 X 23.11 = 0.516 unprocessed PTS takes annually

For the TRACKEX events, our annual estimate of PTS takes is very small (0.0495 based on five 4-hour TRACKEX events), even before mitigation and avoidance factors are applied. Mitigation and avoidance would likely further reduce this estimate. Based on this very small unprocessed annual estimate of PTS takes, the further reduction of PTS to TTS anticipated after factoring in mitigation and avoidance, and the fact that TRACKEX events utilize a single platform and sonar source, we reach the conclusion that the likelihood of sonar exposure from this activity (i.e., single platform TRACKEX) resulting in PTS of humpback whales is extremely unlikely.

For a Small Joint Coordinated ASW event the unprocessed PTS estimate is about an order of magnitude greater than for TRACKEX (0.516 versus 0.0495 takes from above). Thus, without avoidance or mitigation, we estimate approximately one humpback whale PTS take could occur every two years from 20 hours of MF1 sonar in the GMAs from a Small Joint Coordinated ASW event. However, since this is an unprocessed or "raw" take estimate, we need to consider how this estimate of PTS may be reduced to TTS after accounting for mitigation effectiveness and avoidance factors.

The Navy's quantitative analysis uses the following formulas to account for mitigation effectiveness (Navy 2018d):

Mitigation Effectiveness = Species Sightability [0–1] x Observation Area [0, 0.5, 1] (5-1) x Visibility [0.25, 0.5, 0.75, 1] x Positive Control [0, 0.5, 1]

and

Number of animals sighted = Mitigation Effectiveness x Model-Estimated Impacts

The number of animals sighted is equivalent to the number of animals that the Navy would avoid exposing to PTS from sonar during a scenario. To account for this in the sonar impact estimates, the Navy corrects the category of predicted impact by shifting that number of PTS impacts to TTS impacts.

For Small Joint Coordinated ASW event the mitigation effectiveness factors are as follows: Observation of Range to PTS = 1; Reduced Visibility = 0.25; Positive Control = 1; Species Sightability (humpback whales) = 0.759 (Navy 2020d).

Based on these inputs we get the following:

Mitigation Effectiveness = 0.759 x 1 x 0.25 x 1 = 0.19

Number of animals sighted = 0.19 x 0.516 = 0.098

Estimated PTS takes with mitigation applied = 0.516 – 0.098 = 0.418

Next, we need to consider how this estimate (0.418 PTS annually) may be further reduced after applying avoidance factors. The following discussion from the Navy's acoustic effects analysis technical report explains the reduction in PTS takes (to TTS) based on avoidance factors: "Animals present beyond the range to onset PTS for the first three to four pings are assumed to avoid any additional exposures at levels that could cause PTS. This equates to approximately 5 percent of the total pings or 5 percent of the overall time active; therefore, 95 percent of marine mammals predicted to experience PTS due to sonar and other transducers are instead assumed to experience TTS" (Navy 2018d).

For a SQS-53C (i.e., bin MF1) sonar transmitting for 30 seconds at three kHz and a source level of 235 dB re 1 μPa2-s at 1 m, the average range to PTS for low-frequency cetaceans extends from the source to a range of 65 m (Navy 2018d). The 30 second transmittal period was chosen based on examining the maximum amount of time a cetacean would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 meters per second.

Applying the Navy's 95 percent avoidance reduction factor to our estimated PTS takes above (i.e., 0.418 after mitigation applied) we get:

Estimated PTS takes with mitigation and avoidance factors applied = 0.418 x 0.05 = 0.0209

Thus, if we assume that 95 percent of humpback whales predicted to experience PTS due to MF1 sonar within the GMAs would instead experience TTS, our annual estimate of PTS (0.0209) is sufficiently small as to conclude that the likelihood of sonar exposure from a Small Joint Coordinated ASW event resulting in PTS of humpback whales is extremely unlikely.

However, the Navy's approach to accounting for avoidance does not address possible differences in avoidance capability based on an animal's life-stage or particular life function at the time of exposure. Mother-calf pairs on the calving grounds may less capable of avoiding additional exposures at levels that could cause PTS, as compared to individual adult males or females

without calves. The age of the calf may also be a factor in the avoidance capability of a mother-calf pair (e.g., neonates may be particularly vulnerable). Mother-calf pairs may respond differently to MF1 sonar at close range. We are not aware of any studies that have addressed this particular question and, in general, there is very little information available in the scientific literature on the response of humpback whale mother-calf pairs to acoustic stressors. Other potential stressors (e.g., presence of breeding males, other nearby vessel activity, or potential predators) may influence how they respond to acoustic stressors. As such, the assumption that 95 percent of whales predicted to experience PTS due to sonar and other transducers are instead assumed to experience TTS, may not apply to mother-calf pairs on the calving grounds, and, therefore, may result in an underestimate of PTS takes of mother-calf pairs. While our conclusion that the likelihood of PTS from a Small Joint Coordinated ASW is extremely unlikely applies to individual whales (non mother-calf pairs), it may not apply to humpback whale mother-calf pairs.

From above, with mitigation effectiveness applied (but before an avoidance factor is applied), we estimated 0.418 annual PTS takes (all life stages) of humpback whales within the GMAs from 20 hours of MF1 sonar during a Small Joint Coordinated ASW event. From our analysis above, we estimated that about 56 percent of the humpback whale takes within the GMAs would be of mothers and calves combined (i.e., 28 percent mothers and 28 percent calves). We apply this proportion to our PTS take estimate from above to estimate the annual number of PTS takes of mother-calf pairs with mitigation applied (but without an avoidance factor) as follows: 0.418 x 0.56 = 0.234.

We do not have available information to quantify how the avoidance reduction factor may differ for mother-calf pairs on the calving grounds from the 95 percent used in the Navy's quantitative analysis. If we assume that mother-calf pairs on the calving grounds would be able to avoid additional exposures at levels that could cause PTS at the same rate as other humpback whales (i.e., 95 percent avoidance), the resulting estimate is 0.012 PTS takes per year (i.e., 0.234 x 0.05 = 0.012). As discussed above, this may be an underestimate since mother-calf pairs may not respond to MF1 sonar in the same way as other whales. If we take a more conservative approach and assume that mother-calf pairs on the calving grounds would only be able to avoid additional exposures at levels that could cause PTS about one-half of the time as compared to other humpback whales (i.e., 47.5 percent avoidance versus 95 percent), the resulting estimate is 0.111 PTS takes per year (i.e., 0.234 x 0.475), or about one PTS exposure every nine years. Since we anticipate that both mother and calf would be exposed to PTS simultaneously, we estimate about one incident resulting in two PTS takes (i.e., take of the mother and the calf) every nine years. This approach to estimating PTS takes conservatively assumes that the Navy would conduct the maximum level of MF1 sonar (20 hours from December through April) annually as part of a Small Joint Coordinated ASW event. See below for a summary of the key assumptions that went into our analysis of the effects of sonar on humpback whales in the GMAs.

In summary, while mother-calf humpback whale pairs within the GMAs could be exposed to MF1 sonar during a Small Joint Coordinated ASW event at levels that would result in PTS, incidents of PTS are anticipated to be very rare. Based on our conservative assumptions, (including the maximum MF1 sonar hours during Small Joint Coordinated ASW events within the GMAs, and assumptions regarding mother-calf pair sonar avoidance capabilities), we estimate up to one PTS exposure of a mother-calf pair (i.e., two takes) approximately every nine years is reasonably certain to occur as a result of the proposed action.

Summary of Key Assumptions Made for Estimating Humpback Whale Takes in the GMAS

Below we summarize the assumptions and other considerations used in our approach for estimating the take of humpback whales from MF1 sonar use within the GMAs:

1. For purposes of our effects analysis, we assume that the same animal cannot be taken more than once over a 24-hour period.
2. MF1 sonar hours are only restricted within the GMAs (i.e., 20 hours annually from Dec-Apr). As such, the same humpback whales within the GMAs may be exposed to additional hours of MF1 sonar when they are outside of the GMAs.
3. Whales are expected to move around (within GMAs, shallow-waters, and offshore). While whales are expected to be exposed (to MF1 sonar) in deeper waters throughout the five months of residence in these known breeding areas, the potential of whales being exposed to MF1 sonar - outside of the surveyed areas - is expected to be greatest during migration.
4. TRACKEX and Small Joint Coordinated ASW activities would only be conducted in areas greater than three nautical miles from land. From Hill et al. (2020b), the large majority of recent humpback whales sightings within the GMAs have been within three miles from land (see Figure 16 and Figure 17 above). Depending on the location of the ship and of the whales relative to three nautical mile exclusion line, given the ranges to effects (i.e., 898 m to TTS and 65 m to PTS for low-frequency cetaceans) it is possible that mother/calf pairs within three nautical miles from shore could be exposed to MF1 sonar from ships operating outside the three nautical mile limit at levels resulting in TTS or PTS.
5. The Navy's proposed action does not include a depth limitation for TRACKEX or Small Joint Coordinated ASW activities (only a distance from shore limitation, as noted above). Therefore, we conservatively assume that humpback whale mother-calf pairs in very shallow areas (including areas less than 50 meters deep) could be exposed to MF1 sonar from Navy vessels at levels resulting in TTS, and possibly PTS, depending on the distance from the source and the bathymetry of the surrounding area.
6. The mark/recapture abundance estimates provided by the PIFSC represent "snapshots" of abundance for the periods surveyed. As such, these estimates may not fully capture the number of whales associated with the study area throughout the entire five month period

from December through April. The short annual sampling period relative to the length of the winter breeding season, the unknown site-fidelity of whales in the area, whale movement in and out of the study area, variability in the timing of whale migration from year to year, undetected whales due to survey conditions and/or potential unseen animals which may be evasive (mother/calf pairs) and sampling variability and bias are all important factors to consider.

7. Due to the evasive nature of mother-calf pairs on the breeding/calving grounds, they could be difficult to detect and go unnoticed by Navy Lookouts during ASW training events.
8. Abundance estimates are for the entire survey area (839 km2), provided in Hill et al. (2020a), are not restricted to the two GMAs. These estimates assume the whales move freely within the waters off Saipan and beyond. Therefore, there are no GMA-specific exposure (take) estimates. As a result, estimates of exposure for individual GMAs are based on the survey area abundance estimates. While whales are not restricted to the GMAs, the vast majority (approximately 98 percent) of all sightings did occur within the GMAs (either Chalan Kanoa Reef or Marpi Reef).
9. The length of residency of individual humpback whales within these shallow-water areas around Saipan are not known, but are expected to be similar to other studies that report site-fidelity. Other studies have reported individual humpback whale site-fidelity can range from 18-55 days in Columbia (Capella et al. 1995), up to 21 days in Brazil (Baracho-Neto et al. 2012), and greater than 30 days in the Cape Verde Islands (Wenzel et al. 2020).
10. The abundance estimates used represent the best scientifically-available data because they are action area specific and are considered more robust than a non-model approach (e.g. sightings per unit of effort approach).
11. These takes estimates are based on the conservative assumption that all animals within the GMAs (i.e., estimated abundance of 61 whales) would be available every day to exposure to MF1 sonar.
12. Our annual estimates of behavioral harassment and TTS takes are based on either five TRACKEX events each using 4 hours of MF1 sonar or 20 hours of MF1 sonar over a five-day Small Joint Coordinated ASW event (or some combination of the two activities) within the GMAs from December through April. This assumes the maximum level of MF1 sonar use (i.e., 20 hours) in the GMAs from December through April would be conducted during these events on five different days. Our annual estimate of PTS takes is based on the assumption that the maximum level of MF1 sonar use (i.e., 20 hours) in the GMAs from December through April would be conducted annually as part of a Small Joint Coordinated ASW event. As discussed above, our estimate of PTS takes would likely be lower if the 20 hours (or some portion of those hours) were used for TRACKEX events involving a single platform.

13. Our estimate of PTS (i.e., up to one mother-calf pair take every nine years) is based on the conservative assumption that mother-calf pairs on the calving grounds would be able to avoid additional exposures at levels that could cause PTS about one-half of the time as compared to other humpback whales.

Response Analysis

At the start of this section (Section 8.2.1) we described the range of potential responses of ESA-listed cetaceans to sonar and other transducers associated with the proposed action. Given the above estimated exposures of ESA-listed cetaceans to sonar and other transducers associated with the proposed action, in this section we describe the likely responses of these species to this exposure. This includes behavioral responses and sound-induced hearing loss (i.e., TTS and PTS), as well as other possible responses (e.g., stress) that cetaceans may exhibit to exposure to sound fields from sonar and other transducers. Our aim with this response analysis is to assess the potential responses that might reduce the fitness of individual ESA-listed cetaceans. In doing so, we consider and weigh evidence of adverse consequences, as well as evidence suggesting the absence of such consequences. We start with a general discussion of how the ESA-listed cetaceans (in general) considered in this opinion are expected to respond to sonar and other transducers. We then discuss humpback whale mother-calf responses to Navy sonar on the breeding/calving grounds in more detail.

In cases where data on the responses of the ESA-listed cetaceans considered during consultation to sonar and other transducers are not available, we rely on data from other closely-related species. Further, we rely on information on the responses of ESA-listed cetaceans, as well as other related species, to anthropogenic sound sources other than military sonars (e.g., seismic air guns). We recognize that there can be species and sound-specific responses, and even within species, not all individual animals are likely to respond to all sounds in the same way. Nonetheless, by examining the range of responses that ESA-listed and other related cetacean species exhibit to anthropogenic sounds, we incorporate uncertainty in our analysis that stems from intra- and inter-species response heterogeneity and make use of the best available science.

Hearing Threshold Shifts

Whether or not a hearing threshold shift will impact an individual animal's fitness depends on the duration, frequency, and magnitude of the shift. 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 are permanent (e.g., PTS) or last for a long time, occur at a frequency utilized by the animal for acoustic cues, and are of a profound magnitude. A hearing threshold shift of limited duration, occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues would likely have no effect on an animal's fitness.

The frequencies affected by hearing loss will vary depending on the frequency of the fatiguing noise, with frequencies at and above the noise frequency most strongly affected. As described previously, the Navy uses sonars operating at a wide range of frequencies (i.e., from low frequency sources to extremely high frequency sources). Cetaceans that experience 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 cetacean has hearing loss, social calls from conspecifics could be more difficult to detect or interpret if they fell in the octave band of the sonar frequency. Killer whales are a primary predator of mysticetes. Some hearing loss could make killer whale calls more difficult to detect until hearing recovers. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether hearing loss would affect a mysticete's ability to locate prey or rate of feeding. Odontocetes do use sound to find and capture prey underwater. Therefore, it could be more difficult for odontocetes (e.g., sperm whales) with TTS to locate food for a short period before their hearing recovers.

The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to several days to fully recover, depending on the magnitude of the initial threshold shift. Instances of TTS resulting from Navy training and testing activities are expected to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Though there is uncertainty, this relatively short recovery time is supported by available information from the literature (e.g., Finneran 2015). Exposures resulting in TTS are expected to be short term and of relatively low received level because of animal avoidance and the transient nature of most Navy sonar sources. Because TTS would likely be minor to moderate (less than 20 dB of TTS) and last for a short period of time, costs would likely not be consequential to the animal long term. Behavioral research indicates that cetaceans most often will avoid sound sources at levels that would cause hearing loss, particularly more severe instances of TTS or PTS. Additionally, most Navy sonar sources are not stationary, minimizing the likelihood that an animal would remain in close proximity to the source for periods of time that could result in more severe instances of TTS (i.e., because cetaceans generally avoid loud sources of anthropogenic sound). Despite these factors that are expected to minimize the severity of TTS, we assume that some (see Table 71 for estimates) blue, fin, humpback, sei, and sperm will experience TTS as the result of being exposed to sonar and other transducers from Navy training and testing activities. As is the nature of TTS, such effects would be temporary and exposed individuals' hearing is expected to return to normal within minutes to days.

Also important to consider is the potential for repeat instances of TTS due to exposure to Navy sonar. In some exposure scenarios, it is possible that a particular animal will be exposed to sonar resulting in TTS and then, prior to being fully recovered, will be exposed again at a level

resulting in TTS. Experimental studies have not explored such scenarios, so there is uncertainty as to how long recovery would take in these particular cases. Since we don't know what the condition of the animal's hearing is at the time of first exposure, it is possible that in some instances a minor TTS could exacerbate an already sensitive or vulnerable animal, thus increasing the risk of more severe effects.

Behavioral Responses

A behavioral response function is used in NAEMO to quantify the number of behavioral responses that could qualify as a significant behavioral disruption. Under the behavioral response function, a wide range of behavioral reactions may qualify as significant, including but not limited to avoidance of the sound source, temporary changes in vocalizations or dive patterns, temporary avoidance of an area, or temporary disruption of feeding, migrating, or reproductive behaviors. The estimates calculated using the behavioral response functions (see Table 71) do not differentiate between the different types of potential reactions, nor the significance of those potential reactions. These estimates also do not provide information regarding the potential fitness or other biological consequences of the reactions on the affected individuals. Therefore, our analysis considers the available scientific evidence to determine the likely nature of modeled behavioral responses and potential fitness consequences for affected individuals.

The range of behavioral responses due to sonar exposure was presented earlier in this section. There are two general categories of information available regarding the likely responses of cetaceans to sonar exposure: 1) information from controlled exposure experiments, and 2) information from opportunistic observations during the operation of real world sonar. The research shows that cetacean response to acoustic disturbance varies, depending on the characteristics of the sound source, the animal's experience with the sound source, and their behavioral state (e.g., migrating, breeding, feeding) at the time of the exposure.

As presented in a review by Southall et al. (2016), common responses to sonar during controlled exposure experiments include avoidance of the area of sonar exposure, cessation or modification of vocal behavior, and cessation of foraging. More minor reactions have also been observed including alerting to the sound source and startle responses. Southall et al. (2016) found that many, but not all responses of cetaceans to sonar observed so far have been relatively mild and/or brief. For example, both Goldbogen et al. (2013) and Melcon et al. (2012) indicated that behavioral responses to simulated or operational sonar were temporary, with whales resuming normal behavior quickly after the cessation of sound exposure. Further, responses were discernible for whales in certain behavioral states (i.e., deep feeding), but not in others (i.e., surface feeding). In summarizing the response of blue whales to mid-frequency sonar, Goldbogen et al. (2013) states, "We emphasize that elicitation of the response is complex, dependent on a suite of contextual (e.g., behavioral state) and sound exposure factors (e.g., maximum received level), and typically involves temporary avoidance responses that appear to abate quickly after sound exposure." If individual ESA-listed cetaceans briefly respond to

underwater sound from Navy training and testing (e.g., by slightly changing their behavior or temporarily relocating a short distance), the effects can be considered a behavioral response, but are unlikely to be significant to the animal unless that interruption is repeated many times. However, Southall et al. (2016) noted the short-term experiments designed to elicit behavioral responses from cetaceans due to sonar exposure were deliberately designed not to harm the affected animals.

Melcon et al. (2012) reported that baleen whales (i.e., blue whales) exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls (D calls) usually associated with feeding behavior. They were unable to determine if suppression of D calls reflected a change in their feeding performance or abandonment of foraging behavior and indicated that implications of the documented responses are unknown. Goldbogen et al. (2013) speculated that if the documented temporary behavioral responses interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would likely still be available in the environment in most cases following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007).

While the Navy implements a series of mitigation measures to minimize high level sonar exposures during training and testing events, the responses of animals to real world Navy sonar could vary from the small scale, short-term controlled exposure experiments reviewed by Southall et al. (2016). Most of the studies reviewed by Southall et al. (2016) involved a single platform transmitting sonar or another sound source for a short period of time. This is in contrast to what would be expected during some Navy activities (e.g., MTEs) involving sonar where multiple vessels are operating concurrently in close proximity, during an exercise that lasts for an extended period of time (i.e., multiple days to weeks). The response of an animal to an initial exposure during such an event may be different than what could be expected if an animal is exposed multiple times or for a long period of time during an event. Additionally, while these studies can implement controls for some variables (e.g., the distance and movement of the source), they also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, intentionally following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation.

Because of the limitations associated with controlled exposure experiments, it is also important to consider studies that opportunistically observed the response of cetaceans to real world Navy sonar. Passive acoustic monitoring and visual observational behavioral response studies have been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Deakos and Richlen 2015; Henderson et al. 2016; Manzano-Roth et al. 2016; Martin et al. 2015; Mccarthy et al. 2011; Mobley and Deakos 2015; Moretti et al. 2014; Tyack et al. 2011b). Collectively, these studies have indicated that responses vary, and include avoidance of the area of sonar exposure, cessation or modification of vocal behavior, changes in dive behavior, and cessation of foraging.

In addition, some aerial, visual, and acoustic monitoring is conducted before, during and after training events to ascertain whether behavioral responses occurred or could be observed during training and look for injured or stranded animals after training (Campbell et al. 2010; Farak et al. 2011; HDR 2011b; Navy 2011b; Navy 2013a; Navy 2014b; Navy 2015b; Norris et al. 2012b; Smultea and Mobley 2009; Smultea et al. 2009; Trickey et al. 2015). During all of these monitoring efforts, only a few behavioral responses have been observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed, but typically before the event, or appeared to have been deceased prior to the event; Smultea et al. 2011). However, it should be noted that passive acoustic studies are limited to observations of vocally-active cetaceans and visual studies are limited to what can be observed at the surface. These study types do have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies.

Humpback whale's reactions to MFAS have recently been reported from the Pacific Missile Range Facility on Niihau, Hawaii. During February 2018, six satellite tags were deployed on humpback whales prior to the Submarine Commanders Course, and five of the six whales were exposed to MFAS during the event (Henderson et al. 2019b; Martin et al. 2019a). Four of the five tagged whales (assumed males) showed some bouts of extreme movements (e.g., rapid bursts and high turning angles); only one of the five tagged whales had a statistically significant change in behavior relative to MFAS. At the onset of MFAS (max received level of 158 dB re 1μPa), this tagged whale was traveling north onto the range, changed direction and began traveling south, while executing a series of steep dives of increasing depths. Received levels estimated at the bottom of each dive indicated that levels were lower during these deeper dives, possibly in an attempt to reduce received levels while moving away from the source. Once MFAS stopped, dive behavior returned to normal and the whale returned to its original northbound travel (Henderson et al. 2019b; Martin et al. 2019a).

The limitations of opportunistic observations (e.g., limited to observations of vocally-active cetaceans or animals at the surface, limited ability to monitor animal activity long-term, limited ability to control other variable which could impact animal behavior [e.g., prey distribution]) result in some uncertainty as to the likely responses of ESA-listed cetaceans due to sonar exposure. Forney et al. (2017) noted that species that respond to noise (e.g., from military sonars)

by avoiding an area are unlikely to be observed using traditional methods (e.g., lookouts or passive acoustic monitoring) because animals react at distances far greater than the detection range of these methods. They suggest that individuals that are observed must be considered relatively tolerant of anthropogenic noise.

In summary, the available information indicates a range of behavioral responses to sonar may occur for cetaceans, but most responses are expected to be brief, with the animal returning to baseline behavior shortly after the exposure is over. However, as noted by Forney et al. (2017), there is uncertainty due to the limitations of observing cetacean response to sonar in the wild.

Masking (auditory interference)

The potential effects of masking were described earlier in this section. Some limited masking could occur due to the Navy's use of sonar and other transducers when animals are in close enough proximity. That is, if an animal is close enough to the source to experience TTS or a significant behavioral disruption, we anticipate some masking could occur. As stated previously, masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking from noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically-mediated cooperative behaviors such as foraging or reproductive activities.

Because traditional military sonars typically have low duty cycles, the effects of such masking are expected to be limited. The typical duty cycle with most tactical anti-submarine warfare is about once per minute with most active sonar pulses lasting no more than a few seconds (Navy 2013b). This indicates biologically-relevant sounds for individuals in close proximity would only be masked intermittently for a short time.

Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for sperm whales, but as explained above, these effects would only happen close to the source. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high frequency acoustic sources such as pingers that operate at higher repetition, also operate at lower source levels. While the lower source levels of these systems limit the range of impact compared to more traditional systems, animals close to the sonar source could experience masking on a much longer time scale than those exposed to traditional sonars. However, this effect would only occur if the animals were to remain in close proximity to the source.

Non-auditory Physical or Physiological Responses

The available research on the potential for sonar or other sources of anthropogenic noise to result in physiological responses (e.g., stress) is described earlier in this section. Relatively little information exists on the linkage between anthropogenic sound exposure and stress in cetaceans, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Increased stress has been documented as a result of both acute (e.g.,

Romano et al. 2004) and chronic (e.g., Rolland et al. 2012) anthropogenic noise. As described previously, though there are unknowns regarding the occurrence of acoustically induced stress responses in cetaceans, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Humpback Mother-Calf Pair Responses to Sonar on the Breeding Grounds

During the migration to and from the breeding/calving grounds, adult humpback whales are not feeding and therefore rely on energy stores to fuel the long (8 to 9 month) journey. Pregnant females have been estimated to expend approximately 65 percent of their energy stores during these migrations (Braithwaite et al. 2015). On the migration back to the feeding grounds, females must make frequent stops to nurse their calves. Increases in energy expenditure, therefore, can impact the reproductive success of these animals and their ability to complete the migration cycle before energy stores are depleted.

Adult female humpback whales need an area of refuge where they are undisturbed and able to rest and nurse their young. The time spent on the breeding/calving grounds is a critical period during which neonatal calves must acquire sufficient energy via suckling from their fasting mothers to survive the long return journey. In a study of humpback whale mother-calf pairs on their breeding grounds, Bejder et al. (2019) found lactating humpback whales keep their energy expenditure low by devoting a significant amount of time to rest. Their energy expenditure, inferred from respiration rates, is approximately half that of adults on the foraging grounds. Lactating females mainly rest while stationary at shallow depths, often in areas with commercial ships, increasing the potential for ship strike collisions. Even moderate increases of noise, from vessels and other anthropogenic sources, can decrease the time spent resting and can further affect the communication range of humpback whales, including mothers and calves.

Videsen et al. (2017) reported that vocalizations between mother and calf, which included very weak tonal and grunting sounds, were produced more frequently during active dives than suckling dives, suggesting that mechanical stimuli rather than acoustic cues are used to initiate nursing. Their study suggests that the use of mechanical cues for initiating suckling and low level vocalizations with an active space of less than 100 meters indicate a strong selection pressure for acoustic crypsis. Furthermore, such inconspicuous behavior likely reduces the risk of exposure to eavesdropping predators and male humpback whale escorts that may disrupt the high proportion of time spent nursing and resting, and hence ultimately compromise calf fitness. Finally, the information reported by Videsen et al. (2017) suggests that the small active space of the weak calls between mother and calf is very sensitive to increases in ambient noise from anthropogenic disturbance, thereby increasing the risk of mother-calf separation.

The broader implications of this behavior are that an increase in the disturbance level from noise-generating human activities, such as whale watching, shipping and fishing, may increase the risk of mother–calf pair separation, reducing the time available for suckling, or require that louder contact calls are made which, in turn, increases the possibility of detection. These noise-

generating factors include - although not specified - other anthropogenic factors such as naval sonar and vessel traffic. In either case, increased ambient noise could have negative consequences for calf fitness (Cartwright and Sullivan 2009; Craig et al. 2014).

Few behavioral response studies have specifically looked at the response of mother-calf pairs to anthropogenic noise, with most studies focusing on adult animals without calves. Information regarding the responses of mother-calf pairs to anthropogenic noise is unclear at best. McCauley et al. (2003; cited by (Dunlop et al. 2018)) found that resting humpback whale mother-calf pairs showed avoidance responses to seismic airguns at relatively low received levels (129 dB re 1 μPa2·s).

(Sivle et al. 2015) reported that during a severity response study a tagged female (with calf) exposed to naval sonar exhibited avoidance behavior, and the calf was seen moving with the mother. The severity was considered to have the potential to affect vital rates in humpback whales (Sivle et al. 2015). This study was conducted on the feeding grounds and was indicative of a calf with much greater swimming abilities after having already made the migration from the calving grounds.

Humpback whales may also display avoidance behavior by leaving an area where MF1 sonar exposure occured. By leaving the shallow-water areas, the mother and calf could be exposed to even greater risks, including additional MF1 and other Navy sonar sources outside the GMAs, exposure to potential predators, and the separation of the calf from the mother. A significant response to MF1 sonar by a mother with a calf (e.g., as described at PMRF regarding a male humpback by (Henderson et al. 2019b) could result in serious consequences to the mother-calf bond.

Separation of the mother and calf can expose the mother to harassment by male humpback whales seeking breeding opportunities, increasing the energy expenditure of the mother, and can result in continued separation from the calf. The separation of the mother and calf could also result in the calf having greater exposure to the potential risk of ship strike in and around Saipan anchorage area. This risk can increase if the animals are moving to avoid other disruptions such as sonar.

Also important to consider is the potential for repeat instances of TTS due to exposure to Navy sonar. The Navy indicated that it is possible for more than one TRACKEX event to occur on one day or for TRACKEX events to occur on back-to-back days. 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. Since we don’t know what the condition of the animal’s hearing is at the time of first exposure, it is possible that in some instances a minor TTS could exacerbate an already sensitive or vulnerable animal, thus increasing the risk of more severe effects. There are

no known studies which have examined the potential effects of TTS on a humpback whale calf, but disruption of the communication with the mother – and separation as discussed above – can result in secondary detrimental effects to the calf.

Based on our exposure analysis above, we anticipate that a very small number of MF1 exposures within the GMAs could result in PTS of mother-calf humpback whale pairs. Since humpback whales are highly dependent on acoustic cues for several vital life history functions, PTS could lead to fitness consequences. In general, long-term fitness consequences are more likely to occur to individual animals from hearing threshold shifts that are permanent (e.g., PTS) as opposed to temporary. Other important factors in determining if fitness consequences are likely to occur from PTS include the magnitude of the hearing loss, and whether the hearing threshold shift is within the frequency range utilized by the animal for acoustic cues. PTS occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues would likely have no effect on an animal's fitness. Although we cannot quantify the magnitude of PTS, given the Navy's proposed procedural mitigation measures for active sonar, the short PTS range to effects (i.e., 65 meters) for low-frequency cetaceans from MF1 sonar (Navy 2018d), and the anticipated vessel speed, incidents of PTS are expected to of relatively low magnitude.

Explosives

As described previously in Section 5.1.2, explosives include, but are not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column. Mines and demolition charges could be detonated in the water column or on the ocean bottom. Most detonations would occur in waters greater than three nautical miles from shore, and often in areas designated for explosive use.

Assessing whether an explosive detonation may disturb or injure a cetacean involves understanding the characteristics of the explosive sources, the cetaceans that may be present near the sources, the physiological effects of a close explosive exposure, and the effects of impulsive sound on cetacean hearing and behavior. Many other factors besides just the received level or pressure wave of an explosion such as the animal's physical condition and size; prior experience with the explosive sound; and proximity to the explosion may influence physiological effects and behavioral reactions.

The potential range of effects from explosions include death, physical injury or trauma, observable behavioral response, and stress response that may not be detectable. Injury can occur to organs or tissues of an animal. Permanent or temporary hearing loss may occur as well. Stress can help an animal cope with changing conditions, but too much stress can result in negative physiological effects. Behavioral responses range from brief distractions to avoidance of a sound

source to prolonged flight. The sections below provide additional background on the potential effects of explosives on cetaceans. In our exposure and response analyses below, we use this information to discuss the likely effects of Navy MITT explosive use on ESA-listed cetaceans.

Non-Auditory Injury

Explosive injury to cetaceans would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Corey et al. 1943; General 1991; Richmond et al. 1973). The near instantaneous high magnitude pressure change near an explosion can injure an animal where tissue material properties significantly differ from the surrounding environment, such as around air-filled cavities such as in the lungs or gastrointestinal tract. Large pressure changes at tissue-air interfaces in the lungs and gastrointestinal tract may cause tissue rupture, resulting in a range of injuries depending on degree of exposure. The lungs are typically the first site to show any damage, while the solid organs (e.g., liver, spleen, and kidney) are more resistant to blast injury (Ward and Clark 1943). Recoverable injuries would include slight lung injury, such as capillary interstitial bleeding, and contusions to the gastrointestinal tract. More severe injuries, such as tissue lacerations, major hemorrhage, organ rupture, or air in the chest cavity (pneumothorax), would significantly reduce fitness and likely cause death in the wild. Rupture of the lung may also introduce air into the vascular system, producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to critical organs.

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. See Appendix B (Acoustic and Explosive Concepts) in the MITT Draft EIS/OEIS (Navy 2019d) for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

The only known occurrence of mortality or injury to a cetacean due to a Navy training or testing event involving explosives occurred in March 2011, in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area had been used for underwater demolitions training for at least three decades without prior known incident. On this occasion, a group of approximately 100 to 150 long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a NEW of 8.76 lbs (3.97 kg) placed at a depth of 48 ft (14.6 m). Approximately one minute after detonation, three animals were observed dead at the surface. The Navy recovered those animals and transferred them to the local stranding network for necropsy. A fourth animal was

discovered stranded and dead 42 NM to the north of the detonation three days later. It is unknown exactly how close those four animals were to the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Leger 2011). Since that incident, the Navy has implemented additional mitigation measures to minimize the risk of such an event occurring again.

Relatively little is known about auditory system trauma in cetaceans resulting from explosive exposure, although it is assumed that auditory structures would be vulnerable to blast injuries. Auditory trauma was found in two humpback whales that died following the detonation of a 5,000 kg 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). These results may not be applicable to the anatomical adaptations for underwater hearing in cetaceans. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue damage distinct from threshold shift or other auditory effects.

Controlled tests with a variety of lab animals (mice, rats, dogs, pigs, sheep and other species) are the best data sources on actual injury to mammals due to underwater exposure to explosions. In the early 1970s, the Lovelace Foundation for Medical Education and Research conducted a series of tests in an artificial pond at Kirtland Air Force Base, New Mexico to determine the effects of underwater explosions on mammals, with the goal of determining safe ranges for human divers. The resulting data were summarized in two reports (Richmond et al. 1973; Yelverton et al. 1973). Specific physiological observations for each test animal are documented in Richmond et al. (1973). Gas-containing internal organs, such as lungs and intestines, were the principle damage sites in submerged terrestrial mammals; this is consistent with earlier studies of mammal exposures to underwater explosions in which lungs were consistently the first areas to show damage, with less consistent damage observed in the gastrointestinal tract (Corey et al. 1943; Ward and Clark 1943). Results from all of these tests suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

In the Lovelace studies, acoustic impulse was found to be the metric most related to degree of injury, and size of an animal's gas-containing cavities was thought to play a role in blast injury susceptibility. The lungs of most cetaceans are similar in proportion to overall body size as those of terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to cetaceans when scaled for body size. Within the marine mammals, mysticetes and deeper divers (e.g., Kogiidae, Physeteridae, Ziphiidae) tend to have lung to body size ratios that are smaller and more similar to terrestrial animal ratios than the shallow diving odontocetes (e.g., Phocoenidae, Delphinidae) and pinnipeds (Fahlman et al. 2014a; Piscitelli et al. 2010). The use of test data with smaller lung to body ratios to set injury thresholds may result in a more conservative estimate of potential for damaging effects (i.e., lower thresholds) for animals with larger lung to body ratios.

For these shallow exposures of small terrestrial mammals (masses ranging from 3.4 to 50 kg) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than 6 lbs per square inch per millisecond (psi-ms) (40 Pa-s), no instances of slight lung hemorrhage occurred below 20 psi-ms (140 Pa-s), and instances of no lung damage were observed in some exposures at higher levels up to 40 psi-ms (280 Pa-s). An impulse of 34 psi-ms (230 Pa -s) resulted in about 50 percent incidence of slight lung hemorrhage. About half of the animals had gastrointestinal tract contusions (with slight ulceration, i.e., some perforation of the mucosal layer) at exposures of 25-27 psi-ms (170-190 Pa-s). Lung injuries were found to be slightly more prevalent than gastrointestinal tract injuries for the same exposure.

The Lovelace subject animals were exposed near the water surface; therefore, depth effects were not discernible in this data set. In addition, this data set included only small terrestrial animals, whereas marine mammals may be several orders of magnitude larger and have respiratory structures adapted for the high pressures experienced at depth. Goertner (1982) examined how lung cavity size would affect susceptibility to blast injury by considering both cetacean size and depth in a bubble oscillation model of the lung. Animal depth relates to injury susceptibility in two ways: injury is related to the relative increase in explosive pressure over hydrostatic pressure, and lung collapse with depth reduces the potential for air cavity oscillatory damage. The period over which an impulse must be delivered to cause damage is assumed to be related to the natural oscillation period of an animal's lung, which depends on lung size.

Because gas-containing organs are more vulnerable to primary blast injury, adaptations for diving that allow for collapse of lung tissues with depth may make animals less vulnerable to lung injury with depth. Adaptations for diving include a flexible thoracic cavity, distensible veins that can fill space as air compresses, elastic lung tissue, and resilient tracheas with interlocking cartilaginous rings that provide strength and flexibility (Ridgway 1972). Older literature suggested complete lung collapse depths at approximately 70 m for dolphins (Ridgway and Howard 1979) and 20 to 50 m for phocid seals (Falke et al. 1985; Kooyman et al. 1972). Follow-on work by Kooyman and Sinnett (1982), in which pulmonary shunting was studied in harbor seals and sea lions, suggested that complete lung collapse for these species would be about 170 m and about 180 m, respectively. More recently, evidence in sea lions suggests that complete collapse might not occur until depths as great as 225 m; although the depth of collapse and depth of the dive are related, sea lions can affect the depth of lung collapse by varying the amount of air inhaled on a dive (Mcdonald and Ponganis 2012). This is an important consideration for all divers who can modulate lung volume and gas exchange prior to diving via the degree of inhalation and during diving via exhalation (Fahlman et al. 2009). Indeed, there are noted differences in pre-dive respiratory behavior with some cetaceans exhibiting pre-dive exhalation to reduce the lung volume [e.g., phocid seals (Kooyman et al. 1973)].

High instantaneous peak pressures can cause damaging tissue distortion. Goertner (1982) suggested a peak overpressure gastrointestinal tract injury criterion because the size of gas

bubbles in the gastrointestinal tract are variable, and their oscillation period could be short relative to primary blast wave exposure duration. The potential for gastrointestinal tract injury, therefore, may not be adequately modeled by the single oscillation bubble methodology used to estimate lung injury due to impulse. Like impulse, however, high instantaneous pressures may damage many parts of the body, but damage to the gastrointestinal tract is used as an indicator of any peak pressure-induced injury due to its vulnerability.

Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 μPa peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects (Christian and Gaspin 1974). Around 200 psi, the shock wave felt like a blow to the head and chest. Data from the Lovelace Foundation experiments show instances of gastrointestinal tract contusions after exposures up to 1,147 psi peak pressure, while exposures of up to 588 psi peak pressure resulted in many instances of no observed gastrointestinal tract effects. The lowest exposure for which slight contusions to the gastrointestinal tract were reported was 237 dB re 1 μPa peak. As a vulnerable gas-containing organ, the gastrointestinal tract is vulnerable to both high peak pressure and high impulse, which may vary to differing extents due to blast exposure conditions (i.e., animal depth, distance from the charge). This likely explains the range of effects seen at similar peak pressure exposure levels and shows the utility of considering both peak pressure and impulse when analyzing the potential for injury due to explosives.

Hearing Loss and Auditory Injury

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss may vary depending on the exposure frequency, with frequencies at and above the exposure frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies.

Hearing loss has only been studied in a few species of cetaceans, although hearing studies with terrestrial mammals are also informative. There are no direct measurements of hearing loss in cetaceans due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. General research findings regarding TTS and PTS in cetaceans are discussed above in Section 8.2.1 under *Sonar and Other Transducers*.

Physiological Stress

Cetaceans naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is

too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction).

There are no direct measurements of physiological stress in cetaceans due to exposure to explosive sources. General research findings regarding physiological stress in cetaceans due to exposure to sound and other stressors are discussed in detail above in Section 8.2.1 under *Sonar and Other Transducers*. Because there are many unknowns regarding the occurrence of acoustically induced stress responses in cetaceans, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Masking

Masking can also result from exposure to sound from Navy explosives. There are no direct observations of masking in cetaceans due to exposure to explosive sources. General research findings regarding masking in cetaceans due to exposure to sound and other stressors are discussed above in Section 8.2.1 under *Sonar and Other Transducers*. Due to the short duration of sound from explosives, the potential for explosives to result in masking that would be biologically significant is limited.

Behavioral Reactions

Impulsive signals such as explosives, 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. In fact, any stimuli in the environment can cause a behavioral response in cetaceans, including noise from explosions. There are few direct observations of behavioral reactions from cetaceans due to exposure to explosive sounds. Lammers et al. (2017) recorded dolphin detections near naval mine neutralization exercises and found that although the immediate response (within 30 seconds of the explosion) was an increase in whistles relative to the 30 seconds before the explosion, there was a reduction in daytime acoustic activity during the day of and the day after the exercise within 6 km. The nighttime activity did not seem to be different than that prior to the exercise, and two days after there appeared to be an increase in daytime acoustic activity, indicating a rapid return to the area by the dolphins (Lammers et al. 2017).

Vallejo et al. (2017) report on boat-based line-transect surveys which were run over ten years in an area where an offshore wind farm was built; these surveys included the periods of preconstruction, construction, and post-construction. Harbor porpoise were observed throughout the area during all three phases, but were not detected within the footprint of the windfarm during the construction phase, and were overall less frequent throughout the Action Area. However, they returned after the construction was completed at a slightly higher level than in the preconstruction phase. Furthermore, there was no large-scale displacement of harbor porpoises

during construction, and in fact their avoidance behavior only occurred out to about 18 km, in contrast to the approximately 25 km avoidance distance found in other windfarm construction and pile driving monitoring efforts.

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-air gun 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).

NAEMO assumes that significant behavioral responses to solitary explosions are not anticipated due to the short duration of acoustic exposure from such explosions. There has been very little research conducted on this topic. Depending on numerous factors (e.g., proximity, attentional focus, charge weight of blast, and experience of the animal) the responses of individuals may vary and we would assume some animals would exhibit more of a reaction than others. The mitigation measures that would be implemented (such as exclusion zones) are expected to reduce the potential for significant behavioral responses to occur from exposure to solitary explosions.

Mysticetes

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 (Gordon et al. 2003a; McCauley et al. 2000b; Richardson et al. 1985b; Southall et al. 2007). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin and bowhead whales. For the purposes of this analysis, due to the limited amount of data available, we assumed that these responses are representative of all baleen whale species. 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.

Migratory behavior seems to lead to a higher likelihood of response, with some species demonstrating more sensitivity than others do. For example, migrating gray whales showed avoidance responses to seismic vessels at received levels between 164 and 190 dB re 1 μPa (Malme et al. 1986; Malme et al. 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of 5 to 8 km from a seismic array during observational studies and

controlled exposure experiments in one Australian study (McCauley et al. 1998) and up to 3 km from a source vessel moving directly across their migratory path (Dunlop et al., 2017), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al. 2015). 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 et al., 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 air gun 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 air guns 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 μPa, 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 μPa peak-to-peak). Bowhead whales seem to be the most sensitive species, perhaps due to a higher overlap between bowhead whale distribution and seismic surveys in Arctic and sub-Arctic waters, as well as a recent history of being hunted. While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al. 1995b), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 μPa. Additionally, Malme et al. (1988) observed clear changes in diving and breathing patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 μPa. Bowhead whales may also avoid the area around seismic surveys, from 6 to 8 km (Koski and Johnson 1987, as cited in Gordon et al. 2003b) out to 20 or 30 km (Richardson et al. 1999). However, work by Robertson (2014) supports the idea that behavioral responses are contextually dependent, and that during seismic operations bowhead whales may be less "available" for counting due to alterations in dive behavior but that they may not have left the area after all.

In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates in western gray whales while resting or diving off the coast of Russia (Gailey et al. 2007; Yazvenko et al. 2007). The increase in vessel traffic associated with the surveys and the proximity of the vessels to the whales did affect the orientation of the whales relative to the vessels and shortened their dive-surface intervals (Gailey et al. 2016). Todd et al. (1996) found no clear short-term behavioral responses by foraging humpbacks to explosions associated with construction operations in Newfoundland, but did see a trend of increased rates of net

entanglement closer to the noise source, possibly indicating a reduction in net detection associated with the noise through masking or TTS. Distributions of fin and minke whales were modeled with a suite of environmental variables along with the occurrence or absence of seismic surveys, and no evidence of a decrease in sighting rates relative to seismic activity was found for either species (Vilela et al. 2016). Their distributions were driven entirely by environmental variables, particularly those linked to prey including warmer sea surface temperatures, higher chlorophyll-a values, and higher photosynthetically available radiation (a measure of primary productivity).

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 at average received SELs of 131 dB re 1 μPa^2s (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, Nieukirk 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 air gun 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 116-129 dB re 1 μPa, and did not decrease at sites further from the seismic surveys (greater than 104 km) where received levels were 99-108 dB re 1 μPa (Blackwell et al. 2013). In fact, bowhead whale calling rates increased at the lower received levels, began decreasing at around 127 dB re 1 μPa^2s cumulative SEL, and ceased altogether at received levels over 170 dB re 1 μPa^2s cumulative SEL (Blackwell et al. 2015).

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. However, 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 Navy impulsive sources. However, Navy impulsive sources would largely be stationary (e.g., pile driving), short term (instantaneous for explosives or for air guns, on the order of hours rather than days or weeks), and lower source level (e.g., swimmer defense air guns) than were found in these studies and so responses would likely occur in closer proximity or not at all.

Odontocetes

Few data are available on odontocete responses to impulsive sound sources, with only a few studies on responses to seismic surveys, pile driving and construction activity available. Based

on the limited available information, odontocetes appear to be less sensitive to impulsive sound than mysticetes, with responses occurring at much closer distances. This may be due to the predominance of low-frequency sound associated with these sources that propagates long distances and overlaps with the range of best hearing for mysticetes but is below that range for odontocetes. The exception to this is the harbor porpoise, which has been shown to be highly sensitive to most sound sources, avoiding both stationary (e.g., pile driving) and moving (e.g., seismic survey vessels) impulsive sound sources out to approximately 20 km (e.g., Haelters et al. 2014; Pirotta et al. 2014). However, even this response is short-term, with porpoises returning to the area within hours after the cessation of the noise.

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic air gun 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 μPa (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 air guns 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 air gun 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 air gun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to air gun impulses within approximately 1 km of the source (Weir 2008). The dolphins were observed at greater distances from the vessel when the air gun was in use, and when the air gun was not in use they readily approached the vessel to bow ride.

Captive bottlenose dolphins sometimes vocalized or were reluctant to return to the test station after exposure to single impulses from a seismic water gun (Finneran et al. 2002). When exposed to multiple impulses from a seismic air gun, some dolphins turned their heads away from the sound source just before the impulse, showing that they could anticipate the timing of the impulses and perhaps reduce the received level (Finneran 2015). During construction (including the blasting of old bastions) of a bridge over a waterway commonly used by the Tampa Bay, Florida stock of bottlenose dolphins, the use of the area by females decreased while males displayed high site fidelity and continued using the area, perhaps indicating differential habitat uses between the sexes (Weaver 2015).

A study was conducted on the response of harbor porpoises to a seismic survey using aerial surveys and C-PODs (an autonomous recording device that counts odontocete clicks); the animals appeared to have left the area of the survey, and decreased their foraging activity within 5 to 10 km, as evidenced by both a decrease in vocalizations near the survey and an increase in vocalizations at a distance (Pirotta et al. 2014; Thompson et al. 2013). The animals returned within a day after the air gun operation ceased, and the decrease in occurrence over the survey

period was small relative to the observed natural seasonal decrease compared to the previous year.

A number of studies (Brandt et al. 2011; Dähne et al. 2014; Haelters et al. 2014; Thompson et al. 2010; Tougaard et al. 2005; Tougaard et al. 2009) found strong avoidance responses by harbor porpoises out to 20 km during pile driving; all studies found that the animals returned to the area after the cessation of pile driving. Kastelein et al. (2013b) exposed a captive harbor porpoise to impact pile driving sounds, and found that above 136 dB re 1 μPa (zero-to-peak) the animal's respiration rates increased, and at higher levels it jumped more frequently. Bergstrom et al. (2014) found that although there was a high likelihood of acoustic disturbance during wind farm construction (including pile driving), the impact was short-term. Graham et al. (2017) assessed the occurrence of bottlenose dolphins and harbor porpoises over different area and time scales with and without impact and vibratory pile driving. While there were fewer hours with bottlenose dolphin detections and reduced detection durations within the pile driving area and increased detection durations outside the area, the effects sizes were small, and the reduced harbor porpoise encounter duration was attributed to seasonal changes outside the influence of the pile driving. Received levels in this area were lower due to propagation effects than in the other areas described above, which may have led to the lack of or reduced response.

Odontocete behavioral responses to impulsive sound sources are likely species- and context-dependent, with most species demonstrating little to no apparent response. Responses might be expected within close proximity to a noise source, under specific behavioral conditions such as females with offspring, or for sensitive species such as harbor porpoises.

Range to Effects

Section 2.2.2 presented information on the criteria and thresholds used to estimate impacts to marine mammals from explosives. Additional information on these criteria is described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a). In this section we present information on calculated range to effects for various explosive sources used by the Navy as part of the proposed action.

The following tables (Table 74 through Table 79) provide range to effects for explosives sources to the criteria and thresholds described in Section 2.2.2 as they were used as inputs into NAEMO. The range to effects are shown for a range of explosive bins from E1 (up to 0.25 lb NEW) to E12 (up to 1,000 lb NEW). Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that will cause a non-auditory injury, PTS, TTS and significant behavioral disruption. Table 74 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury as a function of animal mass and explosive bin (i.e., NEW). Ranges to peak pressure-based injury typically exceed ranges to impulse-based injury. Therefore, the maximum range to effect is not mass-dependent. Animals within these ranges would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and

finally mortality as an animal approaches the detonation point. Ranges to mortality, based on animal mass, are shown in Table 75.

Table 74. Ranges to non-auditory injury resulting from explosives for all cetacean hearing groups by Navy explosive bin (Navy 2018b).

Bin	Range to Non-Auditory Injury (meters) [1]
E1	12 (11–13)
E2	16 (15–16)
E3	25 (25–25)
E4	30 (30–35)
E5	40 (40–65)
E6	52 (50–60)
E7	120 (120–120)
E8	98 (90–150)
E9	123 (120–270)
E10	155 (150–430)
E11	418 (410–420)
E12	195 (180–675)

[1] Average distance to mortality is depicted above the minimum and maximum distances which are in parentheses. Average distance is shown with the minimum and maximum distances due to varying propagation environments. Modeled ranges based on peak pressure for a single explosion generally exceed the modeled ranges based on impulse (related to animal mass and depth); therefore, ranges shown are not animal mass-dependent.

Table 75. Ranges to mortality resulting from explosives for all cetacean hearing groups as a function of animal mass by Navy explosive bin (Navy 2018b).

Bin	Animal Mass Intervals (kg)					
	10	250	1,000	5,000	25,000	72,000
E1	3 (2—3)	0 (0—3)	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
E2	4 (3—4)	1 (0—4)	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
E3	8 (6—10)	4 (2—8)	1 (0—2)	0 (0—0)	0 (0—0)	0 (0—0)
E4	15 (0—35)	9 (0—30)	4 (0—8)	2 (0—6)	0 (0—3)	0 (0—2)
E5	13 (11—40)	7 (4—35)	3 (3—12)	2 (0—8)	0 (0—2)	0 (0—2)
E6	18 (14—55)	10 (5—45)	5 (3—15)	3 (2—10)	0 (0—3)	0 (0—2)
E7	67 (55—160)	35 (18—140)	16 (12—30)	10 (8—20)	5 (4—9)	4 (3—7)
E8	50 (24—90)	27 (9—55)	13 (0—20)	9 (4—13)	4 (0—6)	3 (0—5)
E9	33 (30—35)	19 (13—30)	10 (8—12)	7 (6—9)	4 (3—4)	3 (2—3)
E10	54 (40—170)	24 (16—130)	13 (11—16)	9 (7—11)	5 (4—5)	4 (3—4)
E11	211 (180—500)	108 (60—330)	47 (40—100)	30 (25—65)	15 (0—25)	13 (11—22)
E12	93 (50—290)	35 (20—230)	16 (13—19)	11 (9—13)	6 (5—8)	5 (4—8)

[1] *Distances in meters (m). Average distance to mortality is depicted above the minimum and maximum distances which are in parentheses. Average distance is shown with the minimum and maximum distances due to varying propagation environments.*

Table 76 through Table 79 show the minimum, average, and maximum ranges to onset of auditory (i.e., TTS and PTS) and behavioral effects from explosives based on the thresholds described in Section 2.2.2. Ranges are provided for a representative source depth and cluster size for each bin. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure-based ranges are estimated using the best available data. Data on peak pressure at far distances from explosions are very limited.

Table 76. Sound exposure level based ranges to PTS, TTS, and behavioral response for low-frequency cetaceans (Navy 2018b).

Range to Effects for Explosives: Low-Frequency Cetaceans[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E1	0.1	1	51 (50–55)	231 (200–250)	378 (280–410)
		18	183 (170–190)	691 (450–775)	934 (575–1,275)
E2	0.1	1	66 (65–70)	291 (220–320)	463 (330–500)
		5	134 (110–140)	543 (370–600)	769 (490–950)
E3	0.1	1	113 (110–120)	477 (330–525)	689 (440–825)
		12	327 (250–370)	952 (600–1,525)	1,240 (775–4,025)
	18.25	1	200 (200–200)	955 (925–1,000)	1,534 (1,275–1,775)
		12	625 (600–625)	5,517 (2,275–7,775)	10,299 (3,775–13,025)
E4	10	2	429 (370–600)	2,108 (1,775–2,775)	4,663 (3,025–6,025)
	60	2	367 (340–470)	1,595 (1,025–2,025)	2,468 (1,525–4,275)
E5	0.1	20	702 (380–1,275)	1,667 (850–11,025)	2,998 (1,025–19,775)
	30	20	1,794 (1,275–2,775)	8,341 (3,775–11,525)	13,946 (4,025–22,275)
E6	0.1	1	250 (190–410)	882 (480–1,775)	1,089 (625–6,525)
	30	1	495 (490–500)	2,315 (2,025–2,525)	5,446 (3,275–6,025)
E7	28	1	794 (775–900)	4,892 (2,775–6,275)	9,008 (3,775–12,525)
E8	0.1	1	415 (270–725)	1,193 (625–4,275)	1,818 (825–8,525)
	45.75	1	952 (900–975)	6,294 (3,025–9,525)	12,263 (4,275–20,025)
E9	0.1	1	573 (320–1,025)	1,516 (725–7,275)	2,411 (950–14,275)

Range to Effects for Explosives: Low-Frequency Cetaceans[1]					
Bin	**Source Depth (meters)**	**Cluster Size**	**Range to PTS (meters)**	**Range to TTS (meters)**	**Range to Behavioral (meters)**
E10	0.1	1	715 (370–1,525)	2,088 (825–28,275)	4,378 (1,025–32,275)
E11	45.75	1	1,881 (1,525–2,275)	12,425 (4,275–27,275)	23,054 (7,025–65,275)
	91.4	1	1,634 (1,275–2,525)	5,686 (3,775–11,275)	11,618 (5,525–64,275)
E12	0.1	1	790 (420–2,775)	2,698 (925–25,275)	6,032 (1,025–31,275)
		4	1,196 (575–6,025)	6,876 (1,525–31,275)	13,073 (3,775–64,275)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Table 77. Peak pressure based ranges to PTS and TTS for low frequency cetaceans (Navy 2018b).

Range to Effects for Explosives: Low-Frequency Cetaceans[1]			
Bin	**Source Depth (meters)**	**Range to PTS (meters)**	**Range to TTS (meters)**
E1	0.1	135 (130–140)	249 (220–270)
E2	0.1	173 (120–180)	305 (180–330)
E3	0.1	292 (240–310)	499 (330–550)
	18.25	310 (310–310)	583 (550–600)
E4	10	396 (390–420)	738 (725–750)
	60	420 (380–775)	846 (575–2,025)
E5	0.1	451 (310–525)	740 (410–1,025)
	30	521 (490–600)	971 (925–1,025)
E6	0.1	547 (350–700)	842 (460–1,275)
	30	622 (600–650)	1,025 (1,025–1,025)

Range to Effects for Explosives: Low-Frequency Cetaceans[1]			
Bin	**Source Depth (meters)**	**Range to PTS (meters)**	**Range to TTS (meters)**
E7	28	927 (900–950)	1,524 (1,275–1,525)
E8	0.1	799 (450–925)	1,030 (575–1,775)
	45.75	1,025 (1,025–1,025)	1,778 (1,525–2,025)
E9	0.1	947 (500–1,275)	1,294 (675–3,025)
E10	0.1	1,032 (550–1,775)	1,388 (800–4,275)
E11	45.75	1,778 (1,525–2,025)	3,067 (2,275–11,275)
	91.4	1,676 (1,275–3,275)	2,442 (2,025–3,525)
E12	0.1	1,151 (625–2,525)	1,762 (900–5,275)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Table 78. SEL-based ranges to PTS, TTS, and behavioral disturbance for mid-frequency cetaceans (Navy 2018b).

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]					
Bin	**Source Depth (meters)**	**Cluster Size**	**Range to PTS (meters)**	**Range to TTS (meters)**	**Range to Behavioral (meters)**
E1	0.1	1	25 (25–25)	116 (110–120)	199 (190–210)
		18	94 (90–100)	415 (390–440)	646 (525–700)
E2	0.1	1	30 (30–35)	146 (140–170)	248 (230–370)
		5	63 (60–70)	301 (280–410)	481 (430–675)
E3	0.1	1	50 (50–50)	233 (220–250)	381 (360–400)
		12	155 (150–160)	642 (525–700)	977 (700–1,025)
	18.25	1	40 (40–40)	202 (190–220)	332 (320–350)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
		12	126 (120–130)	729 (675–775)	1,025 (1,025–1,025)
E4	10	2	76 (70–90)	464 (410–550)	783 (650–975)
	60	2	60 (60–60)	347 (310–675)	575 (525–900)
E5	0.1	20	290 (280–300)	1,001 (750–1,275)	1,613 (925–3,275)
	30	20	297 (240–420)	1,608 (1,275–2,775)	2,307 (2,025–2,775)
E6	0.1	1	98 (95–100)	430 (400–450)	669 (550–725)
	30	1	78 (75–80)	389 (370–410)	619 (600–650)
E7	28	1	110 (110–110)	527 (500–575)	1,025 (1,025–1,025)
E8	0.1	1	162 (150–170)	665 (550–700)	982 (725–1,025)
	45.75	1	127 (120–130)	611 (600–625)	985 (950–1,025)
E9	0.1	1	215 (210–220)	866 (625–1,000)	1,218 (800–1,525)
E10	0.1	1	270 (250–280)	985 (700–1,275)	1,506 (875–2,525)
E11	45.75	1	241 (230–250)	1,059 (1,000–1,275)	1,874 (1,525–2,025)
	91.4	1	237 (230–270)	1,123 (900–2,025)	1,731 (1,275–2,775)
E12	0.1	1	332 (320–370)	1,196 (825–1,525)	1,766 (1,025–3,525)
		4	572 (500–600)	1,932 (1,025–4,025)	2,708 (1,275–6,775)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Table 79. Peak pressure based ranges to PTS and TTS for mid-frequency cetaceans (Navy 2018b).

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	43 (40–45)	84 (80–90)
E2	0.1	58 (55–60)	105 (95–110)
E3	0.1	98 (95–100)	183 (170–190)
	18.25	100 (100–100)	180 (180–180)
E4	10	120 (120–120)	255 (250–260)
	60	123 (120–130)	239 (230–340)
E5	0.1	155 (150–160)	288 (270–300)
	30	168 (160–190)	310 (290–350)
E6	0.1	197 (190–210)	359 (320–400)
	30	200 (200–200)	380 (380–380)
E7	28	296 (290–300)	525 (525–525)
E8	0.1	333 (310–340)	574 (440–625)
	45.75	351 (350–370)	629 (625–725)
E9	0.1	442 (370–460)	757 (500–850)
E10	0.1	546 (420–700)	939 (550–1,275)
E11	45.75	662 (650–800)	1,104 (1,025–1,275)
	91.4	748 (600–1,525)	1,353 (1,000–2,525)
E12	0.1	663 (470–725)	1,064 (625–1,275)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin	**Source Depth (meters)**	**Range to PTS (meters)**	**Range to TTS (meters)**

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Exposure and Response Analysis

In this section we discuss the estimated number of exposures of ESA-listed cetaceans to explosives that are expected to rise to the level of take (e.g., injury, hearing impairment, or significant behavioral disruptions) under the ESA, the expected magnitude of effect from those exposures, and the likely responses of the animals exposed to those effects. The exposure estimates uses for our effects analysis were produced by the Navy based on NAEMO.

Exposure Estimates

As was done for sonar and other transducers (see discussion above), we considered estimates of cetacean exposures to the effects from explosives, based on the Navy's quantitative approach, at three output points for cetaceans: unprocessed exposure estimates; model-estimated exposures (before mitigation/avoidance applied); and post-processing exposure estimates. Table 70 above shows the total estimated (maximum) number of unprocessed exposures from both acoustic and explosive stressors (i.e., estimates were not broken out between the different acoustic stressors and explosives).

Table 76 shows the post-processing cetacean take estimates by species as a result of MITT activities using explosives conducted annually in the action area. Only the most severe impact expected is quantified in this table (i.e., instances of TTS are expected to have an associated behavioral response but these are not counted in the behavioral response column). Exposure to explosives at levels that would result in ESA take are only anticipated for Western Pacific DPS humpback whales and sei whales. No ESA-listed cetacean mortality, non-auditory injury, or PTS is anticipated from the use of explosives during MITT activities. There is a potential for impacts to occur anywhere within the action area where the effects from explosives and ESA-listed cetacean species overlap. Figure 55 and Figure 56 show the proportional distribution of the TTS and behavioral response exposure estimates (from Table 71) by region (as shown in Figure 47 above) within the action area and by activity category. Only areas and activity categories where 0.5 percent or greater of the impacts are estimated to occur are presented in these figures.

Table 80. Estimated ESA-listed cetacean impacts per year from explosives during training and testing activities.

Species	Total Estimated Annual Impacts			
	Behavioral Response	TTS	PTS	Injury
Blue Whale	0	0	0	0
Fin Whale	0	0	0	0
Humpback Whale Western Pacific DPS	6	3	0	0
Sei Whale	2	1	0	0
Sperm Whale	0	0	0	0

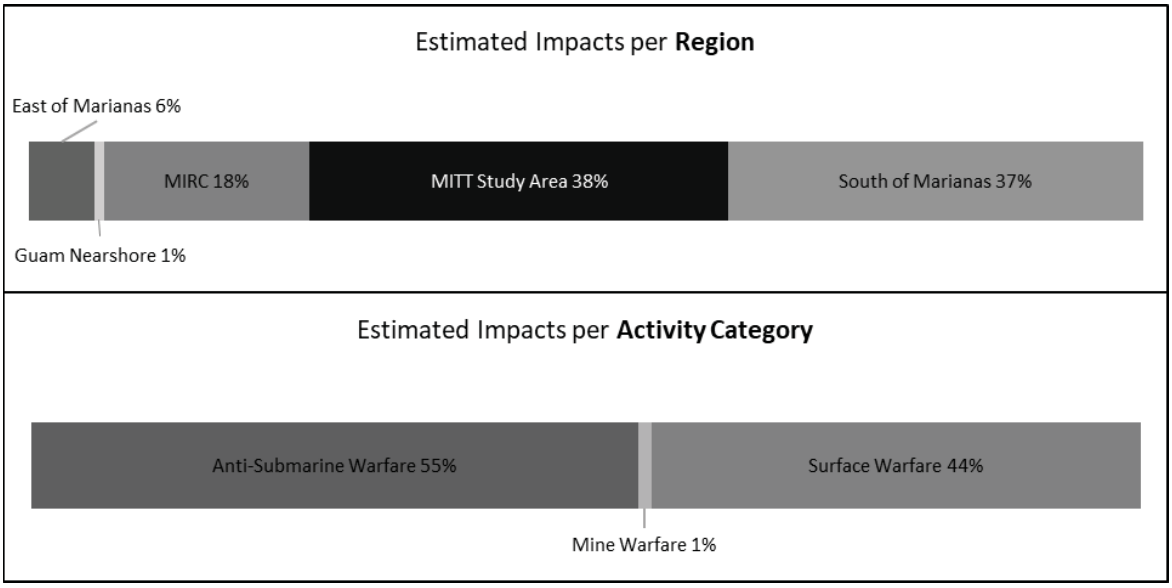


Figure 55. Humpback whale impacts estimated per year from the maximum number of explosions during training and testing under the proposed action.

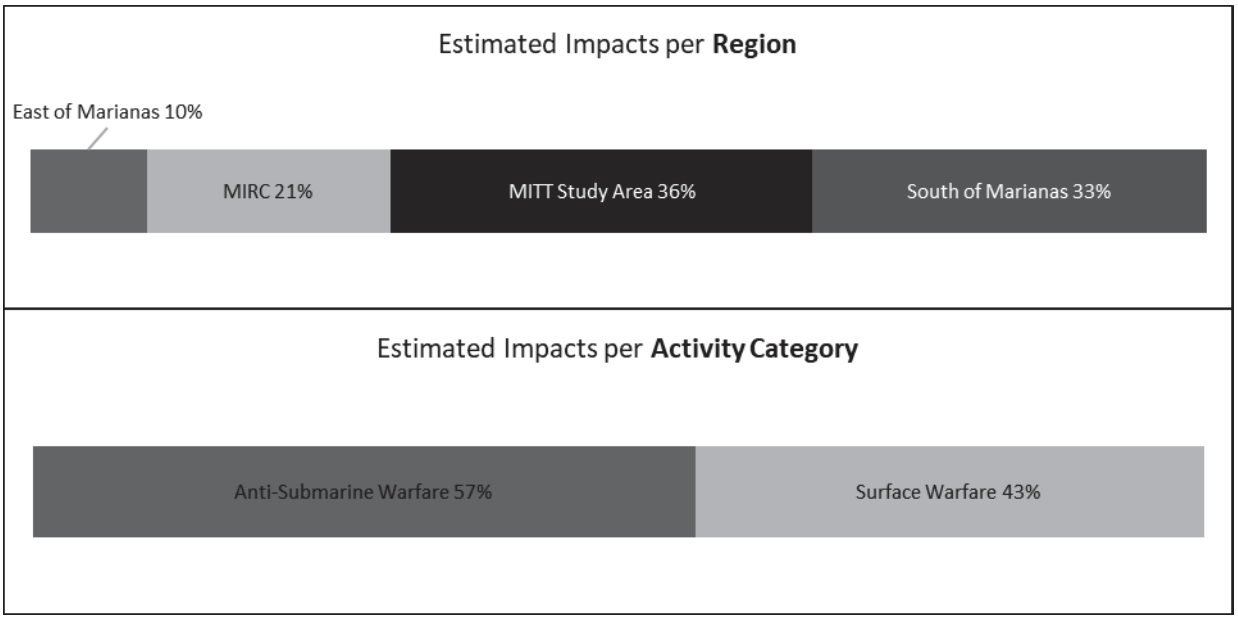


Figure 56. Sei whale impacts estimated per year from the maximum number of explosions during training and testing under the proposed action.

Response Analysis

Above, we described the range of potential responses of ESA-listed cetaceans to explosives associated with the proposed action. Given the above estimated exposures of ESA-listed cetaceans to explosives, in this section we describe the likely responses of these species to this exposure. This includes behavioral response, sound-induced hearing loss (i.e., TTS), as well as other possible responses (e.g., stress) that cetaceans may exhibit as a result of exposure to Navy explosives. As with our response analysis for the effects of sonars, our aim with this response analysis is to assess the potential responses to explosives that might reduce the fitness of individual ESA-listed cetaceans. In doing so, we consider and weigh evidence of adverse consequences, as well as evidence suggesting the absence of such consequences.

Hearing Threshold Shifts

The response of ESA-listed cetaceans from exposure to explosives resulting in TTS is expected to be similar to the response of ESA-listed cetaceans experiencing hearing loss due to sonar or other transducers. The exception is that because active sonar is transmitted at a specified frequency, animal's experiencing TTS from sonar will only experience threshold shifts around that particular frequency. In contrast, explosives are a broadband source, so if an animal experiences TTS from explosives, a greater frequency band will be affected. Because a greater frequency band will be affected due to explosives, there is an increased chance that the hearing impairment will affect frequencies utilized by animals for acoustic cues. The exposure analysis indicates that three exposures to explosives are expected to result in TTS of humpback whales and one exposure to explosives is expected to result in TTS of sei whales, per year as a result of MITT activities. No other ESA-listed cetaceans are expected to experience TTS from Navy explosives in the action area (see Table 76).

Behavioral Response

There are no direct observations of behavioral reactions from cetaceans due to exposure to explosive sounds. General research findings regarding potential behavioral reactions from cetaceans due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Section 8.2.1 above. Behavioral reactions from explosive sounds could be similar to reactions studied for other impulsive sounds such as those produced by seismic air guns (e.g., startle reactions, avoidance of the sound source), but there are important differences in how seismic surveys using air guns are conducted compared with explosive use by the Navy. Seismic surveys using air guns are typically conducted over transects and successive air gun blasts occurring over a sustained period of time. In contrast, Navy explosive use typically involves a single detonation or series of detonations conducted over a short period of time. The available information on the response of humpback and sei whales to explosives indicates animals may alert to the sound source, may alter foraging behavior, or exhibit avoidance behavior. However, these responses are expected to be temporary with behavior returning to a baseline state shortly after the activity using explosives ends. The exposure analysis indicates that six exposures to explosives are expected to result in significant behavioral disruptions of humpback whales and two exposures to explosives are expected to result in significant behavioral disruptions of sei whales, per year as a result of MITT activities. No other ESA-listed cetaceans are expected to experience a significant behavioral disruption from Navy explosives in the action area (see Table 76).

Non-auditory Physical or Physiological Responses

The available research on the potential for explosives or other sources of anthropogenic noise to result in physiological responses (e.g., stress) is described earlier in this section. Relatively little information exists on the linkage between anthropogenic sound exposure and stress in cetaceans, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). However, increased stress has been documented as a result of both acute (e.g., Romano et al. 2004) and chronic (e.g., Rolland et al. 2012) anthropogenic noise. As described previously, though there are unknowns regarding the occurrence of acoustically induced stress responses in cetaceans, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Masking

Some limited masking could occur due to the Navy's use of explosives when animals are in close enough proximity. That is, if an animal is close enough to the source to experience TTS or a significant behavioral disruption, we anticipate some masking could occur. However, masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Given that Navy explosive use typically involves a single detonation or series of detonations conducted over a short period of time, if masking occurs it would likely be a very short-term effect, one which we do not anticipate would result in the reduced fitness of individual ESA-listed cetaceans.

Anticipated Consequences of Sonar and Explosives on Individual Cetaceans Exposed

In the exposure and response analyses above we established that a range of impacts including PTS, TTS, behavioral response, and stress are likely to occur due to exposure to Navy sonar and explosives MITT activities. In this, section we assess the likely consequences of the responses to the individual ESA-listed cetaceans that have been exposed. We determined that the potential effects of masking from sonar are limited because of the duty cycles of most military sonars, the transient nature of sonar use, and the short duration of explosive sound effects. As such, we have concluded that there is little to no risk to cetaceans associated with exposure and response to masking.

Efforts have been made to link short-term effects to individuals due to anthropogenic stressors with long-term consequences to cetacean populations using population models. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. Unfortunately, for acoustic and explosive impacts on cetacean populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and ultimately population-level effects. The Population Consequences of Acoustic Disturbance model (NRC 2005) proposes a conceptual framework for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al. 2016a; Costa et al. 2016b; Harwood et al. 2014; Hatch et al. 2012; New et al. 2014; New et al. 2013a; New et al. 2013b), but the Population Consequences of Disturbance model is still in the preliminary stages of development. Costa et al. (2016b) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. 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.

The long-term consequences due to individual behavioral reactions and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like cetaceans. Of critical importance in discussion on the potential consequences of such effects is the health of the individual animals disturbed, and the trajectory of the population those individuals comprise. The consequences of disturbance, particularly repeated effects, would be more significant if the affected animal were already in poor condition as such animals would be less likely to compensate for additional energy expenditures or lost foraging or reproductive opportunities. However, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences to individuals exposed to the effects of Navy sonars and other transducers as part of the proposed action.

To consider the potential consequences of temporary hearing impacts, behavioral response, and stress to affected animals, we must also consider the context of the exposure and response scenario including the following: 1) the duration of the exposure and associated response, 2) whether or not repeated exposures would be expected, 3) the behavioral state of the animal at the time of the response, and 4) the health of the animal at the time of the response.

Since cetaceans depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators), fitness consequences could occur to individual animals from hearing threshold shifts that last for a long time, occur at a frequency utilized by the animal for acoustic cues, and are of a profound magnitude. A hearing threshold shift of limited duration, occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues would likely have no effect on an animal's fitness. Based on our review of the available literature (discussed above), we expect instances of TTS from Navy sonar to be short-term and of relatively low severity because of animal avoidance and the transient nature of most Navy sonar sources. Because active sonar is transmitted at a specified frequency, animal's experiencing TTS from sonar would only experience threshold shifts around that particular frequency.

In contrast, explosives are a broadband source, so if an animal experiences TTS from explosives, a greater frequency band would be affected. Because a greater frequency band would be affected due to explosives, there is increased chance that the hearing impairment will affect frequencies utilized by animals for acoustic cues. The exposure analysis estimates three annual exposures to explosives resulting in TTS of humpback whales and one annual exposure to explosives resulting in TTS of sei whales. No other ESA-listed cetaceans are expected to experience TTS from Navy explosives in the action area. Given these low exposure numbers, it is unlikely that an individual whale would experience TTS from Navy explosives more than once per year, or possible per lifetime. Thus, adverse effects on acoustic cues resulting from exposure to TTS from explosives would likely be limited in scope and duration for individual whales.

The available literature on cetacean behavioral responses indicate that most responses that have been observed to sonar exposure are of mild to moderate severity, often lasting for the duration of the exposure. Some more severe reactions have been observed, but these have mostly been in cetacean species known to be particularly sensitive to acoustic disturbance (e.g., beaked whales; Southall et al. 2016), which are not listed under the ESA. Based on information available to date, the cetacean species considered in this opinion are not thought to be particularly sensitive to acoustic disturbance. However, it is worth noting that the controlled exposure experiments reviewed by Southall et al. (2016) were deliberately designed to demonstrate the onset of response and not to produce adverse or permanent effects. Additionally, the limitations of opportunistic observations (e.g., limited to observations of vocally-active cetaceans or animals at the surface, limited ability to monitor animal activity long-term, limited ability to control other variables which could impact animal behavior [e.g., prey distribution]) result in some uncertainty as to the severity and duration of likely responses of ESA-listed cetaceans due to sonar exposure. Forney et al. (2017) noted that species that respond to noise (e.g., from military sonars) by avoiding an area are unlikely to be observed using traditional methods (e.g., lookouts or passive acoustic monitoring) because animals react at distances far greater than the detection range of these methods. They suggest that individuals that are observed must be considered relatively tolerant of anthropogenic noise.

The duration and magnitude of the proposed activity is important to consider in determining the likely severity, duration, and potential consequences of exposure and associated response to Navy sonar and explosives. 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. As described further in Section 3.1.9, several categories of training exercises (e.g., MTEs such as Composite Training Unit Exercises) are expected to result in hundreds of hours of sonar activity involving multiple platforms (i.e., surface vessels, submarines, and aircraft) utilizing sonar, as well as the use of explosives. These exercises range in duration from two days to over ten, and therefore have the potential to result in sustained and/or repeat exposure. However, while MTEs may have a longer duration, they are not concentrated in small geographic areas over that time period. MTEs use thousands to tens of thousands of square miles of ocean space during the course of the event. There is no Navy activity in the proposed action that is both long in duration (more than a day) and concentrated in the same location (e.g., within a few square miles), so there is a low likelihood that animals and Navy activities would co-occur for extended periods of time or repetitively over the duration of an activity.

While it is difficult to predict exactly what a cetacean 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. The presence of humpback whales in the nearshore waters of Saipan has been documented since 2007 (Fulling et al. 2011; Hill et al. 2017;

Hill et al. 2018; Hill et al. 2016a; Hill et al. 2019; Klinck et al. 2016; Oleson et al. 2015; Uyeyama 2014). These sightings have been associated with mother/calf pairs, documentation of male singing, and behaviors associated with breeding areas for this species. Breeding areas are known (confirmed in other breeding areas; e.g., Silverbank Dominican Republic) as locations of mother/calf bonding and feeding and serve to allow the mother to reduce the expenditure of energy during a period where her feeding is drastically reduced (Bejder et al. 2019). Disruptions to the mother/calf bonding can create stress and potentially impact the growth of the calf and reduce energy stores of the lactating mother. Regions of low energy expenditure and areas which allow mothers to rest have been shown to be essential for the health of lactating females. Anthropogenic noise can have negative impacts on the energy expenditure of the mother and calf and therefore their migration potential (Bejder et al. 2019).

Currently, the Navy has proposed GMAs which encompass the majority of the humpback whale sightings near Chalan-Kanoa Reef (west of Saipan) and Marpi Reef (north of Saipan). Within these confirmed winter calving areas, the Navy has proposed to not conduct activities involving in-water explosives year-round. The Navy's proposed action includes an annual limit of 20 hours of MF1 sonar within the GMAs from December through April. The Navy has also proposed to report to NMFS annually all sonar use (i.e., number of hour within each sonar bin) in the GMAs as part of their annual classified exercise report (C. Johnson, Navy personal communication to R. Salz, NMFS, May 1, 2020).

Also important to consider is an animal's prior experience with a sound source. The majority of ESA-listed cetaceans exposed to sound from MITT activities have likely been exposed to such sources previously as these activities have been occurring in the Action Area for decades. These exposures likely include ship noise, other types of sonar, seismic surveys, and other Navy activities. These exposures could be experienced during migrations to and from the feeding grounds and on the feeding grounds as well. Harris et al. (2017a) suggested that processes such as habituation, sensitization, or learning from past encounters may lead to stronger or weaker reactions than those of a naïve animal. For example, Baird et al. (2017) found no large-scale avoidance by false killer whales of areas with relatively high mid-frequency active sonar use in the Pacific Missile Range Facility in Hawaii. The authors suggested that since sonar had been used at Pacific Missile Range Facility for over 30 years, it was likely that animals in this area had been exposed to sonar multiple times on previous occasions. The authors suggested that more naïve populations may be more likely to exhibit avoidance responses if exposed to sonar.

When considering the potential consequences of exposure and response to Navy sonar and explosives, we must also take into account the health of the individual animal affected. Individuals that are in good health, with sufficient energy reserves, are likely to be much more resilient when faced with long-term or repeated disturbance than an animal in poor condition. As described in Harris et al. (2017a), one approach to understanding the potential importance of a behavioral response is to consider an animal's energy budget. Cetacean behavioral research has indicated that many species including humpback whales (Sivle 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).

Quantifying the fitness consequences of sub-lethal impacts is exceedingly difficult for cetaceans because of the limitations of studying these species (e.g., due to the costs and logistical challenges of studying animals that spend the majority of time underwater). Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try and quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). A key limitation in these models is that we often do not have empirical data to link sub-lethal behavioral responses to effects on animal vital rates.

Behavioral responses may impact health through a variety of different mechanisms, but most Population Consequences of Disturbance models focus on how such responses affect an animal's energy budget (Farmer et al. 2018; King et al. 2015; NAS 2017; New et al. 2014; Villegas-Amtmann et al. 2017). Responses that relate to foraging behavior, such as those that may indicate reduced foraging efficiency (Miller et al. 2009) or involve the complete cessation of foraging, may result in an energetic loss to animals and thereby expend even more energy to make up for the lost foraging opportunities. Other behavioral responses, such as avoidance, may have energetic costs associated with traveling (Bejder et al. 2019; NAS 2017). Important in considering whether or not energetic losses, whether due to reduced foraging or increased traveling, will affect an individual's fitness is considering the duration of exposure and associated response. Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget and that long duration and repetitive disruptions would be necessary to result in consequential impacts on an animal (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015; NAS 2017; New et al. 2014; Southall et al. 2007; Villegas-Amtmann et al. 2015).

We also recognize that aside from affecting health via an energetic cost, a behavioral response could result in more direct impacts to health and/or fitness. For example, if a cetacean hears Navy sonar or an explosion and avoids the area, this may cause it to travel to an area with other threats such as vessel traffic or fishing gear. However, we find such possibilities (i.e., that a behavioral response would lead directly to a ship strike) to be extremely unlikely and not

reasonably certain to occur due to the low densities of the ESA-listed cetaceans in the action area and the size and relative ease of detection of these species by shipboard observers. Therefore, we focus our risk analysis on the energetic costs associated with a behavioral response.

We would expect many of the anticipated exposures and potential responses of ESA-listed cetaceans to sonar and other transducers and explosives to have little effect on the exposed animals. Based on the controlled exposure experiments and opportunistic research presented above, responses are expected to be short term, with the animal returning to normal behavioral patterns shortly after the exposure is over. However, there is some uncertainty due to the limitations of the controlled exposure experiments and observational studies used to inform our analysis. Additionally, Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. Quantifying the fitness consequences of sub-lethal impacts from acoustic stressors is exceedingly difficult for cetaceans and we do not currently have data to conduct a quantitative analysis on the likely consequences of such sub-lethal impacts. While we are unable to conduct a quantitative analysis on how sub-lethal behavioral effects and temporary hearing impacts may impact animal vital rates (and therefore fitness), based on the best available information, we expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

During exposure, affected animals may be engaged in any number of activities including, but not limited to, migration, foraging, nursing, or resting. If cetaceans exhibited a behavioral response to Navy sonar, these activities would be disrupted and it may pose some energetic cost. However, as noted previously, responses to Navy sonar are anticipated to be short term and instances of hearing impairment are expected to be mild or moderate. Based on best available information that indicates cetaceans resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013; Melcon et al. 2012), we anticipate that exposed animals will be able to return normal behavioral patterns after this short duration activity ceases. Goldbogen et al. (2013) suggested that if the documented temporary behavioral responses interrupted behavior (e.g., as would be expected if a disturbance occurred in the humpback mother/calf pairs near Saipan), this could have impacts on individual fitness and eventually, population health. Males or females without calves could be interrupted during breeding behavior. However, for this to be true, we would have to assume that an individual animal could not compensate for this lost resting/nursing or feeding opportunity by either moving to another location, by stopping the activity until shortly after cessation of acoustic exposure, or by resting/nursing or feeding at a later time. There is no indication this is the case. There would likely be an energetic cost associated with any temporary disruption of humpback whale resting/nursing activities or other cetacean feeding activities to find alternative locations for these to occur. However, unless such disruptions occur over long durations or over subsequent days, we do not anticipate these movement to be consequential to the animal's fitness over the long-

term (Southall et al. 2007). While MTE's could be conducted for up to ten days, activities associated with these exercises are not expected to occur within the nearshore locations where mother/calf humpback pairs have been observed. Also, as discussed above, there is no Navy activity in the proposed action that is both long in duration (more than a day) and concentrated in the same location.

Based on the estimated abundance of the ESA-listed cetaceans that are expected to occur in the action area, and the number of instances of behavioral disruption (i.e., TTS or significant behavioral response) expected from sonar and explosives (i.e., estimates based on Navy modeling), some individuals of these species could be exposed, and respond, to Navy sonar more than once per year (Table 81). The highest number of behavioral disruptions per animal is anticipated to be of the sei whales (i.e., 0.93 disruptions per animal). For all other species, less than 0.60 behavioral disruptions are anticipated per animal annually. This indicates that some or many individuals within the population may not experience a single behavioral disruption per year due to Navy sonar.

Table 81. Estimated number of behavioral disruptions (i.e., TTS or significant behavioral response) from Navy sonar (and other transducers) and explosives per species/DPS in the action area.

Species	Estimated abundance in the action area	Annual behavioral disruptions from active sonar	Annual disruptions per animal
Blue Whale[1]	133	24	0.18
Fin Whale[1]	154	25	0.16
Humpback Whale*	938	777	0.83
Sei Whale[2]	166	154	0.93
Sperm Whale[2]	705	203	0.29

* *(Acebes et al. 2007)*

[1] *Data taken from Bradford et al. (2017)*

[2] *Data taken from Fulling et al. (2011)*

The calculation of the number of disruptions per animal is based on Navy modeling and is a rough approximation of what will occur during Navy training and testing activities in the action area. Therefore, some individuals from each species could experience a few more or less disruptions annually than what is presented. Due to the limitations on acoustic exposure modeling capabilities, we are unable to identify which individual from each population will be exposed to and affected by a particular training or testing event in the action area. For this reason, we are not able to predict exactly how many times each animal in the action area will be exposed to and affected by Navy sonar and explosives annually. The estimates presented in Table 81 above are based on conservative assumptions, and are provided to indicate the relative magnitude of likely exposures on an annual basis.

Based on the estimated abundance in the action area (938, from (Acebes et al. 2007)), humpback whales in the action area would likely experience less than one (0.83) behavioral harassment or TTS take, on average, from acoustic stressors in a given year (although some individuals could be exposed more than once in a particular year and some not at all). However, since the density

of humpback whales in the shallow water breeding/calving grounds from December through April is significantly greater in comparison to other areas, humpback whale mother-calf pairs within the GMAs would likely experience higher take levels. Based on our effects analysis, and assuming the maximum level of MF1 sonar use (i.e., 20 hours) proposed in the GMAs from December through April, we estimate that mother-calf pairs would experience about four TTS and one behavioral harassment take per year on the breeding/calving grounds. There is also the potential for multiple exposures of the same individual on successive days or over a five day event period. We also anticipate a very small number (i.e., about one humpback whale mother-calf pair every nine years) of exposures would result in PTS of humpback whale mother-calf pairs. Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to effect aspects of the affected animal's life functions that do not overlap in time and space with the proposed action. Although we cannot quantify the magnitude of PTS, given the Navy's proposed procedural mitigation measures for active sonar, the short PTS range to effects (i.e., 65 meters) for low-frequency cetaceans from MF1 sonar (Navy 2018d), and the anticipated vessel speed, incidents of PTS are expected to be relatively minor in magnitude.

As discussed above (see *Humpback Mother-Calf Pair Responses to Sonar on the Breeding Grounds*), this level of acoustic disturbance would occur during a particularly sensitive period in the humpback whale's life history when both the mother and the calf are more vulnerable to both natural and anthropogenic stressors. Although we do not have sufficient information to quantify, we believe that a very small number of humpback whale mother-calf pairs would likely experience fitness consequences as a result of MF1 sonar use in the GMAs, and the synergistic effects of this acoustic stressor combined with other stressors during this vulnerable life stage.

With the exception of mother-calf humpback whale pairs within the GMAs (as discussed above), while we anticipate some whales in the action area could experience more than one behavioral disruption per year, they would likely be exposed periodically, and based on the available literature such infrequent exposures are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015; NAS 2017; New et al. 2014; Southall et al. 2007; Villegas-Amtmann et al. 2015). Therefore, we do not expect this level of exposure to impact the fitness of exposed blue whales, fin whales, sei whales, sperm whales, or humpback whales (except mother-calf pairs). Further, we anticipate that any instances of TTS will be of minimum severity and short duration. This conclusion is based on literature indicating that even following relatively prolonged periods of sound exposure resulting in TTS, recovery occurs quickly (Finneran 2015). The brief amount of time cetaceans are expected to experience TTS is unlikely to significantly impair their ability to communicate, forage, or breed and is not expected to have long-term fitness consequences for the individuals affected. Additionally, in general, we do not anticipate these species will experience long duration or repeat exposures within a short period of time due to the species' wide ranging life history and that long duration (i.e., more than one day) Navy activities also occur over large geographic areas (i.e., both the animal and the

activity are moving within the action area, most likely not in the same direction). This decreases the likelihood that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity. Although there is an increased chance that TTS resulting from explosives would affect frequencies utilized by animals for acoustic cues (as compared to TTS from sonar), the Navy's quantitative model predicts very few instances of TTS from explosives. Since it is unlikely that an individual whale would experience TTS from Navy explosives on multiple occasions, adverse effects on acoustic cues resulting from such exposures would likely be limited in scope and duration for individual whales.

In summary, we do not anticipate that instances of behavioral harassment or TTS from Navy activities involving sonar (and other transducers) and explosives would result in long-term fitness consequences to individual blue whales, fin whales, sei whales, sperm whales, or humpback whales (except mother-calf pairs) in the action area. Due to their elevated vulnerability on the breeding/calving grounds, increased potential for multiple exposures over a short period of time, likely reduced avoidance capability, synergistic effects of other stressors, and other reasons discussed above, we anticipate that a very small number of humpback whale mother-calf pairs would likely experience fitness consequences as a result of the Navy's MF1 sonar use in the GMAs.

8.2.2 Sea Turtles

This section discusses the effects of explosives and vessel strike on ESA-listed sea turtles. Additional discussion of explosives as a potential stressor associated with the proposed action is included in Section 5.1.2 above. Additional discussion of vessel strike as a potential stressor associated with the proposed action is included in Section 5.3.1 above.

Explosives

Explosives that may be used as part of the proposed action include bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys (Navy 2019e). Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; and mines and demolition charges could be detonated in the water column or on the ocean bottom (Navy 2018b; Navy 2019e). Most detonations would occur in waters greater than 200 ft deep and greater than three NM from shore, although mine warfare, demolition, and some testing detonations would occur in shallower water, closer to shore. Nearshore mine neutralization and underwater demolition activities involving explosives will be conducted at the Agat Bay, Piti and Outer Apra Harbor UNDETs. Most activities involving the use of explosives would occur in the Mariana Islands Range Complex (Navy 2019e). A small number of training activities involving explosives, including air to surface bombing exercises and surface to surface gunnery exercises, are proposed within the MITT transit corridor. However, given the anticipated small number of events using explosives and the very low sea turtle densities that will likely be present in the action area during that time, it is highly unlikely that sea turtles would be exposed to explosive

stressors in the transit corridor. As such, this area will not be discussed further in our explosives exposure analysis for sea turtles. For details on the levels, locations, and bin sizes of proposed activities involving explosives refer to Section 3 of this opinion.

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. Unlike other acoustic stressors, explosions release energy at a high rate, producing a shock wave that can result in both sublethal and lethal effects on marine animals. Potential impacts include mortality, injury, hearing loss due to threshold shift (permanent or temporary), masking of other biologically relevant sounds, physiological stress, and changes in behavior. Based on what is known about potential sea turtle impacts from explosives studies and other activities that use explosives (e.g. oil and gas exploration), we assume underwater explosives can result in mortality, injury, and impairment of sea turtles that are exposed. Lethal injuries result from massive trauma or combined trauma to internal organs as a result of close proximity to the point of detonation. Types of lethal injuries include massive lung hemorrhage, gastrointestinal tract injuries (contusions, ulcerations, and ruptures), and concussive brain damage, cranial and skeletal (shell) fractures, hemorrhage, or massive inner ear trauma (Ketten 1995). Examples of nonlethal injuries include eardrum rupture, bruising, and immobilization of severely stunned animals. Stunned animals beneath the water may drown or become vulnerable to other impacts while they are immobilized. Minor organ injuries and contusions can also occur as a result of underwater explosions; however, some sea turtles would be expected to recover over time through normal healing processes. Still, delayed complications arising from nonlethal injuries may ultimately result in the death of the animal because of potential increased risks from secondary infection, predation, or disease, and a reduced foraging capacity.

Exposure and Response Analysis

In this subsection we summarize the results from the Navy's NAEMO Phase III exposure model and discuss the anticipated responses (i.e., numbers of individuals taken, types of take anticipated) based on the sea turtle exposure levels predicted by the model. The NAEMO model takes into account (1) criteria and thresholds used to predict impacts from explosives, (2) the density and spatial distribution of sea turtles, and (3) the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation and explosive energy when estimating the received sound level and pressure on the animals. For details on the approach used to evaluate the effects of explosives on sea turtles and model inputs (e.g., turtle density estimates) refer to Section 2.2 of this opinion, the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018d), and the *Navy Marine Species Density Database Phase III for the MITT Study Area* (Navy 2018e).

NAEMO estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation (see Section 3.6.2 for details). Procedural mitigation measures include delaying or ceasing applicable detonations when a sea turtle is observed in a

mitigation zone. The mitigation zones for explosives extend beyond the respective average ranges to mortality. In the quantitative analysis, consideration of procedural mitigation measures means that, for activities where mitigation is feasible, model-estimated mortality is considered mitigated to the level of injury. The impact analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects. The Navy will also implement mitigation measures for in-water explosives within mitigation areas. The benefits of mitigation areas are discussed qualitatively and have not been factored into the quantitative analysis process or reductions in take for the ESA impact estimates.

The numbers of potential impacts estimated for individual species of sea turtles from exposure to explosive energy and sound for MITT activities are shown in Table 82. These exposure estimates represent the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. The quantitative analysis, using a maximum year of training and testing activities, estimates that no sea turtle mortalities or non-auditory injuries would occur as a result of MITT explosive activities. The mortality threshold is based on the exposure level expected to result in extensive lung hemorrhage. The data used to derive the threshold equations for onset of mortality are from Richmond et al. (1973). The injury threshold is based on the exposure level expected to result in onset of a slight lung injury and/or contusions to the gastrointestinal tract. The data and theory used to derive these threshold are from Richmond et al. (1973) and Goertner (1982). There is some uncertainty regarding whether slight lung injuries or contusions to the gastrointestinal tract may have long-term effects on survival rates due to the lack of studies. The Navy's quantitative exposure analysis assumes that sea turtles with slight lung injuries or gastrointestinal tract contusions could survive, whereas those with extensive lung injuries would not (Navy 2017a). In addition to minor lung injuries or gastrointestinal tract contusions from the blast wave, it is possible that sea turtles may be physically injured due to fragmentation of exploding munitions. However, given that fragments would quickly decelerate in water, and that injury due to the blast wave would extend much further than any risk from fragmentation, sea turtles that may experience injury from fragmentation are also assumed to experience injury due to the blast wave. As such, the estimates produced by NAEMO modeling for non-auditory injuries are assumed to encompass any sea turtles that may also be injured due to fragmentation.

The NAEMO model predicts that a small number of green sea turtles (i.e., nine total) would be exposed to levels of explosive sound and energy that could cause PTS and TTS (three PTS and six TTS)(Navy 2019e). The quantitative analysis predicts that no hawksbill, leatherback, or loggerhead sea turtles are likely to be exposed to levels of explosive sound and energy that could cause injury, PTS, or TTS during MITT activities.

Any acoustic stimuli within sea turtle hearing ranges in the marine environment, including noise from explosions, could elicit behavioral responses in sea turtles. The quantitative model predicts that four sea turtle species would be exposed to received levels from explosions that may result in behavioral responses (i.e. at or exceeding 175 dB re 1 μPa SPL (rms)). Up to 2,381 green, 46

hawksbill, one leatherback, and one loggerhead could be exposed annually to explosions that result in a behavioral response. These represent conservative estimates of the number of behavioral responses anticipated since they are based on a maximum year of testing and training activities and not all exposures to the threshold received levels modeled (i.e. 175 dB rms) would necessarily produce a behavioral response.

While there is the potential for impacts to occur anywhere within the action area where sound and energy from explosions and the species overlap, the model predicts 82 percent of all green sea turtle exposures would occur in Outer Apra Harbor, 16 percent East of the Marianas, one percent in the MITT study area, and one percent in nearshore Guam (refer to Figure 48 above for geographic locations) (Navy 2019e). All exposures resulting in TTS or PTS are predicted to occur in the nearshore waters of Outer Apra Harbor (Navy 2019d). Martin et al. (2019b) tracked the movements of green sea turtles (n=16) fitted with satellite tags inside and just outside of Apra Harbor (including capture sites at Orote Point, Dadi Beach, and Piti Bomb Holes). Spatial analysis of the GPS locations from this study did not show direct overlap of the turtles or their core use or home range areas with the Agat Bay Mine Neutralization Site, Piti Point Mine Neutralization Site, and Outer Apra Harbor UNDET. However, the authors note that turtles are spending significant amounts of time in and moving through areas within 1-2 km of these sites, and the lack of overlapping GPS points could be due to the relatively low frequency of GPS locations obtained from these tags (often a maximum of one per day) (Martin et al. 2019b).

In terms of activities, nearly all (98 percent) of the impacts to green sea turtles would result from surface warfare (mine warfare and antisubmarine warfare account for one percent each)(Navy 2019e). Maritime Security Operations, which are conducted in Outer Apra Harbor, account for an estimated 82.1 percent of the green sea turtle behavioral takes resulting from explosive use (i.e., bin E2 or anti-swimmer grenades, 40-mm grenades). Gunnery Exercise Surface-to-Surface Ship Large Caliber exercises, which are conducted offshore, account for an estimated 15.6 percent of green sea turtle behavioral takes from explosives (Navy 2019e).

Since most sea turtle exposures to explosives are predicted to occur in nearshore areas, based on recent studies (Martin et al. 2018; Summers et al. 2018a), we expect the large majority of takes to be of juveniles and subadults. Some small number of adult green sea turtles from the Central West Pacific DPS could also be affected as this population has known nesting sites within the action area. Behavioral harassment due to exposure to explosives of loggerhead and leatherback sea turtles occurring in offshore pelagic waters could also include some adults.

The Navy’s quantitative analysis does not estimate green sea turtle exposures at the DPS level. Most of the Action Area overlaps with the nesting range of the Central West Pacific DPS, and a very large majority of green sea turtles in the action area, particularly in nearshore areas, are expected to be from this DPS. Green turtles from the Central North Pacific DPS also forage in nearshore waters but, based on limited genetic studies, they likely make up a very small proportion of the green sea turtles in the action area. Green sea turtles from the East Indian-West Pacific DPS are expected to occur in the offshore portion of the Action Area due to overlap with

the oceanic and nesting range. Considering that over 80 percent of the estimated impacts from explosives are predicted to occur in nearshore waters (i.e., Outer Apra Harbor), we expect a very large proportion of the estimated exposures to be from the Central West Pacific DPS.

The actual number of sea turtle exposures may be smaller than those estimated in Table 82 due to restricted activities in designated mitigation areas. The Navy will not use in-water explosives during training and testing within the Chalan Kanoa Reef Mitigation Area and the Agat Bay Nearshore Mitigation Area to avoid potential impacts on green and hawksbill turtles. The Navy will also implement mitigation to avoid potential impacts from explosives on seafloor resources, which may help avoid potential impacts on sea turtles that shelter in and feed on shallow-water coral reefs, live hard bottom, reefs, and shipwrecks.

Table 82. Estimated sea turtle impacts per year from MITT explosive activities.

Species	*Annual*			
	Behavioral[1]	*TTS*	*PTS*	*Injury*
Explosive Training Activities				
Family Cheloniidae (hardshell turtles)				
Green turtle[2]	2,381	6	3	0
Hawksbill turtle	46	0	0	0
Loggerhead turtle	1	0	0	0
Family Dermochelyidae (scuteless turtles)				
Leatherback turtle	1	0	0	0

Notes: PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift

[1] *These numbers represent the predicted exposures at or exceeding 175 dB re 1 µPa SPL (rms). We conservatively assume that all such exposures could result in a behavioral response.*

[2] *Exposures may include green sea turtles from the Central West Pacific, East Indian-West Pacific, and Central North Pacific DPSs*

Explosives are a broadband source (Hildebrand 2009), so if a sea turtle experiences TTS or PTS from explosives, a greater frequency band would be affected as compared to TTS or PTS from sonar. 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 (Nelms et al. 2016; Popper et al. 2014), and instead, may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013) and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015). 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 a single TTS exposure would have long-term fitness impacts on individual turtles. PTS 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 PTS may have a reduction in fitness either through some slight decrease in survivorship (e.g., decreased ability to hear predators or hazards such as vessels) or reproduction (e.g., minor effects to navigation that may reduce mating opportunities).

There is very limited data available regarding the behavioral responses of sea turtles to anthropogenic sound sources. Sea turtle behavioral responses to an explosion could include a startle response, leaving an area, avoiding an area, diving, or a disruption of activity (e.g., feeding or resting). As described previously (Section 2.2.5), NMFS conservatively uses the limited information on sea turtle behavioral responses to air guns as a surrogate for the sound sources produced during Navy activities, including explosive exposure analysis. Because sea turtles exhibit avoidance behaviors to air gun exposure at levels above 175 dB rms (re 1 μPa), responses to explosive detonations could be similar. 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 Navy 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. We do not expect this to occur as a result of the Navy's use of explosives during their training and testing exercises. Most explosions 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 (mostly green) sea turtles may experience a behavioral response from exposure to explosives, the anticipated impacts on fitness and survival are minor and short-term.

ESA-listed sea turtles that experience either TTS, PTS, or a strong behavioral response are also expected to experience a physiological stress response. 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 this stressor are expected to be short-term in nature given that in most cases sea turtles would not experience repeated exposure to explosives. As such, we do not anticipate stress responses would be chronic, involve distress, or have negative long-term impacts on any individual sea turtle's fitness.

The Navy will implement mitigation measures (described in Section 3.6.2) which include several Lookout scenarios with large exclusion zones (Navy 2019e). The mitigation for Phase III

includes the following changes from Phase II designed to further minimize impacts from explosives: 1) a 250 yd increase in the mitigation zone size for sonobuoys using up to 2.5 lb NEW so that all explosive sonobuoys will implement a 600 yd mitigation zone, regardless of NEW, 2) a 400 yd increase in the mitigation zone size for surface-to-surface activities using explosive medium-caliber projectiles (now a 600 yd mitigation zone) and large-caliber projectiles (now a 1,000 yd mitigation zone), 3) a 1,100 yd increase in mitigation zone size (now 2,000 yd) for missiles and rockets using 21–250 lb NEW, and 4) an increase in the mitigation zone size during explosive mine neutralization activities involving Navy divers for positive control charges in bin E4 or below. These measures would reduce the number of sea turtles that could be exposed to explosives by ensuring (as much as possible) that sea turtles are not present during exposure to this stressor.

In summary, while all four sea turtle species are expected to experience behavioral and physiological stress responses from exposure to explosives, these responses alone are not expected to have any long-term impacts, nor to affect the fitness of individual sea turtles. The explosives associated with the proposed action are also expected to result in TTS and PTS of a small number of green sea turtles. While individuals from all three green sea turtle DPSs (Central West Pacific, East Indian-West Pacific, and Central North Pacific) could experience TTS and PTS, we expect the large majority of predicted exposures would be from the Central West Pacific DPS. PTS could result in fitness consequences on individual sea turtles exposed. Based on the overall low number of green sea turtles that could experience PTS, we do not anticipate that the use of explosives as proposed by the Navy would have measurable impacts at the population level for any DPS of green sea turtles. For all other sea turtle species in the action area, the predicted effects from explosives would be limited to behavioral responses with no anticipated long-term impacts nor fitness consequences for individual sea turtles.

Vessel Strike

The majority of the Navy's training and testing activities considered in this biological opinion involve vessel activity. While commercial vessel traffic is relatively steady throughout the year, Navy vessel use within the action area is episodic, based on specific exercises being conducted at different times of the year. Any of the sea turtles species present in the action area can occur at or near the surface of the water, and therefore may be susceptible to vessel strike. There are no reported cases of a sea turtle being struck by a Navy vessel in the MITT Action Area. Unlike when a vessel strikes a large whale, it is often difficult to detect when a vessel strikes a turtle. This is due to the relatively small size of a sea turtle compared to the vessels used by the Navy in military readiness training and testing.

Vessel use for Navy training and testing 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 off nesting beaches. Sea turtles are expected to be more highly dispersed in deeper offshore waters and, given the large area over which Navy 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. The Navy will continue to implement procedural mitigation to avoid or reduce the potential for vessel strikes of sea turtles. During Amphibious Warfare Exercises, in addition to maneuvering around observed sea turtles in general, if a sea turtle is sighted within the designated vessel traffic zone the Navy will cease beach approaches until one of the recommencement conditions have been met (see Section 3.6.2, Table 38 for details).

Sea turtle vulnerability to vessel strike increases with vessel speed. 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. In inshore waters (where vessel encounters with sea turtles may be higher), Navy vessel use occurs more regularly and is mainly from small, high-speed vessels. High-speed vessel movements in nearshore and inshore waters present a relatively greater risk of vessel strike because of the higher concentrations of sea turtles in these areas and the difficulty for vessel operators to see them and avoid collisions during high speed activities. The Navy also conducts propulsion testing as part of their activities involving vessels. Although such testing is infrequent, this activity, which can involve ships operating at speeds in excess of 30 knots, may pose a higher strike risk due to the high vessel speeds.

More information on Navy vessel activity and the associated threat of sea turtle vessel strike in the action area can be found above in Section 5.3.1 (*Potential Stressors*), Section 7.9 (*Environmental Baseline*), and in the Navy's MITT Phase III BA (Navy 2019e).

Sea Turtle Vessel Strike Exposure Analysis

Our vessel strike exposure analysis below estimates the number of non-lethal and lethal vessel strikes of each sea turtle species (or DPS) that are anticipated annually as a result of the proposed action. Our approach to this analysis was based on available strandings information (including cause of strandings, as provided) and the relative proportion of 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 Navy vessel activity.

Evaluation of Areas and Activities

Our sea turtle ship strike analysis focuses on the areas of greatest overlap between Navy vessel activity and ESA-listed sea turtles. The areas identified as having the highest ship strike potential are nearshore waters in close proximity to Navy ports. For the MITT Action Area, our analysis focuses on nearshore waters around Guam, particularly Apra Harbor where all Navy MITT vessels are berthed, and the CNMI islands of Saipan and Tinian. Outside of these areas (e.g., deep-water, offshore areas and nearshore areas around small, remote islands), Navy vessel traffic is more sporadic and less dense as vessels travel to locations throughout the wide Action Area to conduct training and testing activities. The density of sea turtles is substantially lower in offshore waters compared to nearshore portions of the Action Area (see Section 2.2.6 above). Sea turtles struck far offshore are less likely to strand than those struck in more nearshore waters. We have

no empirical data to indicate Navy vessels strike turtles in offshore waters of the MITT Action Area or the transit corridor, nor do we have data to indicate what percent of those that may be struck in offshore waters would strand. Since both Navy vessel activity and sea turtle densities are orders of magnitudes lower in offshore portions of the Action Area (as compared to nearshore areas), we expect sea turtle vessel strikes to be extremely rare in such areas. Therefore, our sea turtle vessel strike analysis is based on available information from the nearshore waters off Guam and the CNMI.

Several of the nearshore activities and exercises proposed by the Navy fall under the main activity category of Amphibious Warfare. Amphibious Warfare activities combined account for 60.7 percent of total surface ship days (i.e., 299 days or 7,176 hours) (Navy 2019a). These activities involve amphibious assault ships maneuvering offshore then approaching designated beach landing areas to offload marines in landing craft, amphibious assault vehicles, or helicopters. Typical landing locations, depending on activity type, include Guam, FDM, Rota, Saipan, and Tinian (Tinian Military Lease Area). Given the large proportion of surface ship hours and close proximity of many exercises to shore, Amphibious Warfare activities likely represent the greatest threat to sea turtles from vessel strike of all the Navy activity areas described in Section 3. While other activity areas may include exercises in nearshore waters (e.g., mine warfare, precision anchoring), these activities and exercises make up a much smaller proportion of surface ship hours as compared to Amphibious Warfare (Navy 2019a).

Sea Turtle Species Considered for Quantitative Analysis

Estimated densities of leatherback and loggerhead sea turtles are extremely low in the MITT Action Area (i.e., 0.000022 animals/km^2), and these species are even less likely to occur in the nearshore environments or near major ports where most of the Navy vessel traffic is concentrated. Becker et al. (2019) reported sea turtle observations from 13 years of towed-diver surveys across 53 coral islands, atolls, and reefs in the Central, West, and South Pacific, including sites in the Mariana Archipelago (Tinian, Saipan, Guam, Rota, and Aguijan). No leatherback or loggerhead observations were reported in this study across all surveyed sites. Martin et al. (2018) conducted snorkeling surveys from 2013-2017 in Guam, Saipan, and Tinian (36 total effort days). Out of a total of 375 turtles encountered, none were leatherbacks or loggerheads. The absence of these species in recent strandings data from Guam and the CNMI supports the rare event nature of these species in nearshore waters. Given the very low estimated densities throughout the Action Area, the lack of documented sightings of these species in nearshore waters, and the low likelihood of overlap with Navy vessels in offshore waters, we consider the likelihood of a leatherback or loggerhead sea turtle to be struck during Navy training and testing activities in the MITT Action Area or transit corridor to be so low as to be extremely unlikely. These species, along with olive ridely which was discounted above (see Section 6.1.1), are not discussed further in our vessel strike exposure analysis.

The turtle species most likely to be present in the action area and encounter Navy vessels are green and hawksbill sea turtles. Green and hawksbill sea turtles are more commonly sighted

(both through in-water surveys and strandings) in the Mariana Islands (see *Species Density Estimates* Section 2.2.6), particularly in nearshore environments (Becker et al. 2019; Martin et al. 2016), and therefore have a much higher likelihood of encountering Navy vessels as compared to the other turtle species (i.e., leatherbacks, loggerheads or olive ridleys) in the action area. As such, these two species are carried forward to our quantitative vessel strike exposure analysis below.

Strandings Probabilities

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. For stranded sea turtles with injuries consistent with vessel strike in the action area, we have no information indicating what proportion of those injuries were sustained ante-mortem versus post mortem. 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. While this suggests vessel strike did not occur post-mortem, this is just one study based on a small sample size of stranded turtles. For our analysis, we conservatively assume that vessel strike was the cause of mortality 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 can be highly variable in both space and time (Koch et al. 2013). Juvenile and adult sea turtles have a specific gravity greater than seawater and both adjust their buoyancy by inflating their lungs (Milsom 1975). Consequently, moribund turtles sink to the bottom. As a result of decomposition, the animal will eventually bloat and float to the surface, only to sink again later. Thus, the probability of a moribund turtle beaching in an area is largely dependent upon the near-bottom current field (Epperly et al. 1996).

Previous studies suggest that the stranding probability of a sea turtle that dies at sea usually does not exceed 10 to 20 percent of total at sea mortality, even in nearshore waters (Epperly et al. 1996; Hart et al. 2006; Mancini et al. 2012). 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). Hart et al. (2006) used results from oceanic drift-bottle experiments to validate their predictions and provide an upper limit on sea turtle stranding proportions. Drift bottle return rates in this study suggest an upper limit for the proportion of sea turtle carcasses that strand at around 20 percent. (Epperly et al. 1996) evaluated how well beach strandings functioned as an indicator of fishery-induced mortality. They found that the number of dead turtles that washed up on the beaches represented a maximum of 7-13 percent of the estimated fishery-induced mortalities. They attributed the low stranding probability to offshore bottom currents, which normally transport

lifeless turtles away from the beach during the winter. Depending on currents, wind and other factors, strandings may represent as low as five percent 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 stranding may never be noticed or recorded in a database, particularly in more remote, less populated 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.

The available information does not allow us to quantitatively estimate the percentage of vessel struck turtles that are observed stranded in the action area. We expect the observed stranding probability to be somewhat higher within Apra Harbor compared to other nearshore portions of the Action Area due to the relatively enclosed nature of the harbor and the relatively large human population along the harbor, including the large military presence. As a term and condition of the MITT Phase II biological opinion, the Navy shall notify NMFS if a dead or seriously injured sea turtle is observed during or following testing and training activities. For these reasons, sea turtles that are struck by vessels in Apra Harbor are more likely to both strand and be reported as compared to those struck by vessels around Saipan, Tinian and other parts of Guam. Based on the strandings probability information presented above for other areas, we conservatively apply a ten percent observed stranding probability for sea turtles struck by vessels in Apra Harbor, and a five percent observed strandings probability for sea turtles struck by vessels in the nearshore areas surrounding Saipan, Tinian, and other portions of Guam. These estimates consider: 1) the physical factors (e.g., wind, currents, and bathymetry) in this region that may prevent a carcass from stranding, and 2) the many remote, less populated areas around these islands, some of which could be used for Navy or other vessel activities, where unobserved strandings are more likely to occur. *Proportion of Sea Turtle Ship Strikes Attributed to Navy Vessels*

To estimate the total number of vessel strike mortalities (from all vessels) in the action area, we will combine the available information on the number of reported strandings with evidence of vessel strike (discussed below) with our estimated stranding probability rates from above. For purposes of our effects analysis, we then need to determine what proportion of the total estimated sea turtles killed by vessel strike are attributable to Navy vessels as part of the proposed action. To estimate vessel strikes by Navy vessels we need to determine the proportional level of Navy vessel activity relative to all vessel activity that can result in sea turtle vessel strike. We are particularly interested in the relative proportion of Navy vessel activity within the nearshore areas where sea turtle vessel interactions are more likely to occur.

Navy vessels represent a relatively small amount of overall vessel traffic in the action area. Over the 5-year period between 2014 and 2018, there were cumulatively 1,497 Navy vessel transits through Apra Harbor (or about 299 per year on average). This represents 14 percent of all vessel transits, which, in addition to Navy vessels, includes other military vessels and commercial shipping vessels (Navy 2019e). Since we do not have data to indicate how many smaller,

recreational boats transit through Apra Harbor, we conservatively estimate that Navy vessel traffic accounts for 14 percent of the vessel transits through Apra Harbor (i.e., actual percent may be somewhat smaller).

Vessel activity can be measured several ways, including number of vessels, number of transits in and out of ports, or number of ship-hours on the water. Of these measures, ship-hours on the water is likely the best correlate of sea turtle ship strike risk. All other things being equal (e.g., vessel speed, vessel size, vessel draft, 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. However, the proportion of total vessel operating hours attributed to Navy vessels was not available for our analysis; only information on the relative proportion of vessel transits (through Apra Harbor) was provided in the Navy's BA. Transits in and out of ports could misrepresent ship strike risk since they do not include a temporal component (i.e., a one hour trip and a multi-day trip would both be counted as a single transit). Across all warfare areas and activities, the Navy estimates a total of 11,828 hours (or 493 24-hour days) of surface vessel at-sea time would occur annually within the MITT Action Area (Navy 2019e). Divided by the estimated 299 vessel transits per year (from MITT Phase II), we expect each Navy vessel transit would involve roughly 39.6 hours of at-sea time.

Navy vessel movements in the action area fall into one of two categories: 1) those activities that occur in the offshore component of the Action Area, and 2) those activities that occur in inshore waters. Activities that occur in the offshore component of the Action Area may last from a few hours to a few weeks (Navy 2019e). Vessels participating in offshore Navy activities are expected to spend very little time in the nearshore areas where sea turtle interactions are more likely to occur. The hours spent in nearshore areas by Navy vessels transiting to offshore areas will likely be similar, on average, to the hours spent by commercial vessels transiting to and from Apra Harbor through established shipping routes. Activities that occur in nearshore waters, where sea turtle vessel strikes are more likely to occur, can last from a few hours to up to 12 hours of daily movement per vessel per activity (Navy 2019e). The hours spent in nearshore areas by Navy vessels conducting nearshore activities would likely be greater, on average, than the hours spent by typical commercial vessels transiting through Apra Harbor (exceptions may be commercial fishing vessels that operate in nearshore waters).

Based on these reasons and information provided in the Navy BA, we conservatively estimate that Navy vessel traffic accounts for 14 percent of all vessel transits through Apra Harbor. Next, we need to estimate the proportion of Navy transits through Apra Harbor that are associated with nearshore activities, since, as discussed above, these transits likely misrepresent ship strike risk in terms of at-sea hours as compared to commercial transits. The Navy BA indicates that activities occurring in nearshore waters can last from a few hours to up to 12 hours of daily movement per vessel, while activities occurring in offshore waters can last from a few hours to up to a few weeks. For purposes of this analysis, and lacking more detailed information on nearshore versus offshore vessel hours per transit, we make the following assumptions: 1)

activities that occur in nearshore waters involve, on average, eight hours of daily movement per vessel transit, and 2) activities that occur in offshore waters involve, on average, 120 hours (five days X 24-hours per day) of daily movement per vessel transit.

Based on the Navy's BA, the total estimated surface vessel at-sea time that would occur annually within the MITT Action Area is 11,828 hours. We also know the estimated annual number of vessel transits is 299. Therefore, we can arrive at the number of vessel transits associated with nearshore activities ('x') and the number associated with offshore activities ('y') by solving for the following two equations simultaneously:

Equation 1: $x + y = 299$ (annual Navy transits through Apra Harbor)

Equation 2: $8x + 120y = 11{,}828$ (annual surface vessel at-sea hours across all MITT activities)

Calculations:

$8 (299-y) + 120y = 11{,}828$

$2{,}392 – 8y + 120y = 11{,}828$

$112y = 9{,}436$

$y = 84.3$ = estimated number of vessel transits associated with offshore activities

$x = 214.7$ = estimated number of vessel transits associated with nearshore activities

Based on our calculations above, we estimate that nearly 72 percent (i.e., 214.7/299) of Navy vessel transits through Apra Harbor are associated with nearshore activities. From above, Navy vessels account for an estimated 14 percent of all vessel transits through Apra Harbor. Therefore, Navy vessels associated with nearshore activities account for an estimated ten percent of all vessel transits through Apra Harbor (i.e. $0.72 * 0.14 = 0.10$); Navy vessels associated with offshore activities account for the remaining four percent. As discussed above, the transits by Navy vessels associated with nearshore activities (10 percent of all transits) likely underrepresents sea turtle vessel strike risk in terms of at-sea hours in nearshore areas as compared to commercial transits. From above, we assumed eight hours of at-sea time in nearshore areas, on average, for Navy vessel transits associated with nearshore activities. Lacking more detailed information on commercial vessels, we conservatively estimate two hours of at-sea time in nearshore areas, on average, for commercial vessels transiting through Apra Harbor. This is based on the assumption that most commercial vessels will follow established shipping routes and spend a minimal amount of time in the nearshore areas surrounding Guam and the CNMI. Thus, Navy vessel transits associated with nearshore activities may result in four times the number of at-sea hours in nearshore waters as compared to typical commercial vessel transits (i.e., eight hours versus two hours, on average). Since Navy vessels associated with nearshore activities account for an estimated ten percent of all vessel transits through Apra Harbor, we estimate that these transits account for 40 percent of all at-sea vessel hours in nearshore waters.

Navy vessels associated with offshore activities account for an estimated four percent of all vessel transits through Apra Harbor. As discussed above, the hours spent in nearshore areas by Navy vessels transiting to offshore areas will likely be similar, on average, to the hours spent by commercial vessels. Therefore, the four percent of all vessel transits from Navy vessels associated with offshore activities likely represents about four percent of all at-sea vessel hours in nearshore waters (i.e., no adjustment is needed). We add this four percent (from Navy vessels associated with offshore activities) to the 40 percent from above (from Navy vessels associated with nearshore activities) to arrive at 44 percent of at-sea vessel hours in nearshore waters. Thus, overall we estimate that Navy vessels account for an estimated 44 percent of all surface vessel at-sea hours in the nearshore waters of the MITT Action Area. We use 44 percent as the proportion of the sea turtles killed by vessel strike that are attributable to Navy vessels as part of the proposed action in our analysis below.

Estimated Lethal Vessel Strikes

To estimate the number of lethal vessel strikes of sea turtles resulting from the proposed action we combined the available information from strandings reports with our estimated strandings probability (i.e., ten percent for Apra Harbor, five percent for nearshore portions of Saipan, Tinian and other parts of Guam) and the estimated proportion of surface vessel activity (at-sea hours) in the nearshore waters attributed to Navy vessels (44 percent).

Two sources of available strandings information were available for our analysis. Summers et al. (2018a) summarize strandings data between April 2005 and September 2016 on the islands of Saipan and Tinian. In this study, gross external examination and necropsy of dead turtles was used to infer primary cause of stranding. The second source was a dataset provided by the PIFSC on reported sea turtle strandings in Guam from 2015-2019. To account for likely differences in vessel activity, sea turtle densities, and observed strandings probabilities between Guam and the CNMI, we calculate estimated vessel strikes separately for these two areas based on strandings information from Summers et al. (for Saipan and Tinian) and the PIFSC dataset (for Guam). Similarly, from the Guam dataset, we calculate separate vessels strike estimates for Apra Harbor and the rest of Guam to account for differences that may affect a vessel strike analysis.

We recognize that vessel strikes of sea turtles by Navy vessels could potentially occur in more remote parts of the Action Area not covered by these two data sources (e.g., other CNMI islands such as FDM, Rota and Pagan or offshore areas). As discussed above, vessel strike is much less likely to occur in offshore areas due to the low density of both Navy vessel traffic and sea turtles in these areas. Estimated sea turtle densities are relatively high for some nearshore areas around smaller or more remote islands (e.g., Pagan 39.9, Rota 92.5 green turtles per km^2). However, Navy vessel activity is anticipated to be relatively low and sporadic in nearshore areas of these smaller, remote, and sparsely populated islands as compared to around Guam, Saipan and Tinian. Since we expect the large majority of sea turtle vessel strikes to occur in areas where Navy vessels are concentrated, and given that there is no available information that could be used to

support a vessel strike analysis for other nearshore areas, our vessel strike analysis focuses on the nearshore areas around Guam, Saipan and Tinian.

Saipan and Tinian

Summers et al. (2018a) recorded 89 total sea turtle strandings (86 from Saipan; 3 from Tinian). By species there were 82 greens, five hawksbill, one olive ridley, and one unidentified turtle. The primary cause of stranding in most cases was human induced trauma related to directed take (n=70, 83.3 percent of the 84 cases where cause could be determined). Three strandings (all green turtles) were attributed to vessel strike; three to marine debris entanglement; three to shark bite; three to nutritional deficiencies, and two to infection/inflammation.

Two of the three sea turtles with vessel strike injuries, as reported by Summers et al., were recovered alive. The final condition of the turtles that stranded alive was not provided in this study and is often difficult to determine. 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. Considering these factors, we conservatively include these records in our analysis of lethal vessel strikes to account for the possibility of delayed sea turtle mortalities or serious fitness consequences resulting from vessel strike injuries.

Thus, from Summers et al. (2018a) we estimate the average annual number of sea turtle strandings in Saipan and Tinian due to vessel strike (by all vessels) to be 0.26 turtles (i.e., three strandings / 11.5 years of the study). Based on our observed strandings probability analysis above, we estimate that these 0.26 turtles represent about five percent of the total number of sea turtles in Saipan and Tinian that are struck annually by vessels. Thus, our estimate of the annual number of sea turtle vessel strikes (by all vessels) in Saipan and Tinian is 5.2 sea turtles. The next step is to determine the proportion of this total vessel strike estimate attributable to Navy vessels as part of the proposed action. From above, we estimated that Navy vessels account for roughly 44 percent of all surface vessel at-sea hours in the nearshore waters of the MITT Action Area. Therefore, the estimated number of sea turtle vessel strikes annually by Navy vessels in the nearshore waters off Saipan and Tinian is 2.3 (i.e., 5.2 * 0.44), which we conservatively round up to three turtles.

By species, vessels strikes that occur around Saipan and Tinian would most likely be green sea turtles. Greens accounted for over 92 percent of the strandings recorded by Summers et al. (2018a), while hawksbills accounted for nearly six percent in this study. Similarly, Martin et al. (2018) report from survey data off Guam, Saipan, and Tinian that 94 percent of observed sea turtles were green, with the remaining six percent hawksbills (of those turtles that could be identified to species). The majority of green sea turtles in the action area, particularly in nearshore areas, are expected to be from the Central West Pacific DPS. Most of the Action Area overlaps with the nesting range of this DPS. We conservatively estimate up to three Central West Pacific DPS green sea turtle mortalities annually as a result of Navy vessel strike around Saipan and Tinian. Central North Pacific DPS green turtles and hawksbill mortalities from Navy vessel

strike around Saipan and Tinian are less likely to occur on an annual basis, but could occur over a longer period of time (maybe one per species every 10 to 20 years). Green sea turtles from the East Indian-West Pacific DPS are expected to be found in the offshore portion of the Action Area. Therefore, as discussed above, the likelihood of a Navy vessel strike of an East Indian-West Pacific DPS green turtle is so low as to be considered discountable.

From Summers et al. (2018a), the majority (79.3 percent) of green turtles were juveniles (n = 65), while 17.1 percent (n = 14) were adults (SCL ≥ 81 cm), and 3.6 percent unknown (n =3). All stranded hawksbill turtles were juveniles. Overall, most sea turtle vessel strikes as a result of the proposed action are expected to be juvenile turtles, but adult green sea turtles from the Central West Pacific DPS could also be vulnerable to vessel strike as this population has nesting sites at several locations around Tinian and Saipan.

Guam

We used a 2015-2019 sea turtle strandings dataset provided by the PIFSC as the best available information for estimating vessel strike mortalities around Guam. Information provided in this datasets included species, date, location, time, size, turtle condition (alive or dead) and cause of stranding (as available). As mentioned above, we calculated separate vessel strike estimates for Apra Harbor and the other nearshore portions of Guam to account for likley differences in stranding probability and strike risk.

From the 2015-2019 dataset, there were four sea turtle strandings (all green turtles) reported in Apra Harbor where vessel strike was identified as the likely cause of mortality. One sea turtle that stranded dead in Apra Harbor with an “unknown” cause of stranding was also, conservativley, assumed to be stranded due to vessel strike. Based on our observed strandings probability analysis above, we estimate that these five turtles represent about ten percent of the total number of sea turtles in Apra Harbor that are struck annually by vessels. Thus, our estimate of the number of sea turtle vessel strikes (by all vessels) in Apra Harbor is 50 sea turtles over five years (2015-2019), or ten per year. The next step is to determine the proportion of this total vessel strike estimate attributable to Navy vessels as part of the proposed action. From above, we estimated that Navy vessels account for roughly 44 percent of all surface vessel at-sea hours in the nearshore waters of the MITT Action Area. Therefore, the estimated number of sea turtle vessel strikes annually by Navy vessels in Apra Harbor is 4.4 (i.e., 8 * 0.44), which we conservatively roundup to 5 turtles.

Next, we estimate the number of sea turtle vessel strikes annually by Navy vessels in the other nearshore areas around Guam (i.e., besides Apra Harbor). From the 2015-2019 dataset, there were no sea turtle strandings reported in nearshore areas around Guam, other than Apra Harbor, with vessel strike identified as the likely cause of mortality. There were a few records where casue of stranding was either unconfirmed or unknown. Based on the turtle condition and other comments provided, we determined that of the unconfirmed/unknown records one may have been due to vessel strike. Thus, we conservatively assume that one of the strandings reported in

nearshore areas around Guam (other than Apra Harbor) was caused by vessel strike. Based on our observed strandings probability analysis above, we estimate that this one turtle represent about five percent of the total number of sea turtle strandings around Guam (excluding Apra Harbor). Thus, our estimate of the annual number of sea turtle strandings by vessel strike (all vessels) around Guam (excluding Apra Harbor) is 20 sea turtles over five years (2015-2019), or four per year. The next step is to determine the proportion of this total annual vessel strike estimate attributable to Navy vessels as part of the proposed action. From above, we estimated that Navy vessels account for roughly 44 percent of all surface vessel at-sea hours in the nearshore waters of the MITT Action Area. Therefore, the estimated number of sea turtle vessel strikes annually by Navy vessels in around Guam (excluding Apra Harbor) is 1.76 (i.e., 4 * 0.44), which we conservatively roundup to two turtles. Combining this estimate with the Apra Harbor estimate above (five turtles), yields an estimated seven sea turtle vessel strikes annually by Navy vessels around all of Guam (including Apra Harbor).

By species, vessels strikes that occur around Guam would most likely be green sea turtles. Of the 21 total standings in the 2015-2019 database, 20 (including all vessel strike strandings) were green sea turtles and one was an olive ridley. Martin et al. (2018) report from survey data off Guam, Saipan, and Tinian that 94 percent of observed sea turtles were green, with the remaining six percent hawksbills (of those turtles that could be identified to species). Martin et al. (2016) analyzed long-term trends in sea turtle aerial survey data (1963-2012) from Guam and estimated that 85 percent of sea turtles in Guam are green turtles, and 15 percent are hawksbills. The majority of green sea turtles in the action area, particularly in nearshore areas, are expected to be from the Central West Pacific DPS. Green sea turtles from the East Indian-West Pacific DPS are expected to be found in the offshore portion of the Action Area. Therefore, as discussed above, the likelihood of a Navy vessel strike of an East Indian-West Pacific DPS green turtle is so low as to be considered discountable.

We conservatively estimate up to seven Central West Pacific DPS green sea turtle mortalities annually as a result of Navy vessel strike around Guam, including Apra Harbor. Central North Pacific DPS green turtles and hawksbill mortalities from Navy vessel strike around Guam are much less likely to occur. We estimate up to one Central North Pacific DPS green sea turtle mortality and up to one hawksbill mortality annually as a result of Navy vessel strike around Guam. Similar to Saipan and Tinian, the large majority of sea turtle vessel strikes in Guam as a result of the proposed action are expected to be juvenile turtles (Martin et al. 2018), but adult green sea turtles from the Central West Pacific DPS could also be vulnerable to vessel strike.

Lethal Vessel Strikes for All Areas Analyzed

From above, we estimate up to three Central West Pacific DPS green sea turtle mortalities annually as a result of Navy vessel strike around Saipan and Tinian. We also estimated about one Central North Pacific DPS green turtle and one hawksbill mortality from Navy vessel strike around Saipan and Tinian every 10 to 20 years. For Guam, we estimate up to seven Central West Pacific DPS green sea turtle mortalities annually, and up to one Central North Pacific DPS green

sea turtle mortality and up to one hawksbill mortality annually as a result of Navy vessel strike. For our exposure analysis overall, we estimate 10 lethal vessels strikes of Central West Pacific DPS green sea turtles, about one lethal vessel strike of Central North Pacific DPS green sea turtles, and about one lethal vessel strike of hawksbill sea turtles annually as a result of the proposed action.

Summers et al. (2018a) found that about 18 percent of green sea turtles stranded in Tinian and Saipan were adults (SCL ≥ 81 cm). Applying this proportion (as the best available information) to 10 lethal vessels strikes of Central West Pacific DPS green sea turtles, we estimate about two adult (and 8 juvenile or subadult) Central West Pacific DPS green turtle lethal strikes per year. Based on turtle size information from Summers et al. (2018a) and Martin et al. (2018), we expect all Central North Pacific DPS green and hawksbill turtle lethal strikes to be of juvenile or subadult turtles.

Estimated Non-Lethal Vessel Strikes

Several studies have reported live sea turtles with vessel strike injuries. This indicates that under some circumstances (e.g., very small vessels, slow moving vessels, or a partial vessel strike only grazing a fin or outer shell) vessel strike can result in non-lethal effects on sea turtles that neither strand nor are killed by the interaction. In order to calculate the total number of non-lethal vessel strikes in the action area, we reviewed the literature for reported occurrences of non-lethal vessel strikes. As reported in the literature, the proportion of live sea turtles with non-lethal vessel strike injuries for most populations is around two to four percent (Blumenthal et al. 2009; Deem et al. 2006; Denkinger et al. 2013; Norem 2005), although for one population it was as high as 19 percent (Denkinger et al. 2013). The injuries observed in a population at any given point in time likely occurred over many years, since a turtle can exhibit signs of a non-lethal vessel strike injury for many years after the encounter. Thus, the proportion of a population that experiences a non-lethal vessel strike encounter in any given year (i.e. annual rate) would be much smaller than those reported with such an injury at any single point in time (i.e., a snapshot).

The information needed to directly estimate non-lethal vessel strikes of sea turtles within the action area as a result of the proposed action is lacking. Therefore, we use a ratio of lethal to non-lethal sea turtle vessel strikes based on the ship strike effects analysis conducted by NMFS for the draft biological opinion on the Bureau of Ocean Energy Management's Oil and Gas Program Activities in the Gulf of Mexico (NMFS 2020a). NMFS (2020a) estimates that 25 percent of green sea turtle vessel strikes would be non-lethal and 75 percent would be lethal. Based on the estimated number of Central West Pacific DPS green sea turtle lethal vessel strikes annually by Navy vessels from above (i.e., 10), we estimate there would be 3.3 (25/75 * 10) non-lethal vessel strikes annually of Central West Pacific DPS green turtles as a result of the proposed action. We conservatively round this up to four Central West Pacific DPS green sea turtle non-lethal vessel strikes annually. By life stage, based on Summers et al. (2018a), we would expect about 18 percent (or about one per year) of these would be adult and the rest (about three per year) would be juvenile or subadult turtles.

From above, we also anticipate about one hawksbill and one Central North Pacific DPS green turtle lethal vessel strike per year by Navy vessels in the MITT Action Area. Applying the same approach used for green sea turtles, we estimate there would be 0.33 (25/75 * 1) non-lethal hawksbill and Central North Pacific DPS green turtle vessel strikes annually. We conservatively round these up to one Central North Pacific DPS green sea turtle non-lethal strikes and one hawksbill non-lethal vessel strike per year by Navy vessels as a result of the proposed action. Based on turtle size information from Summers et al. (2018a) and Martin et al. (2018), we expect all Central North Pacific DPS green and hawksbill turtles non-lethal lethal vessels strikes to be with juvenile or subadult turtles.

Sea Turtle Vessel Strike: Summary

We conclude that vessel strike of sea turtles by Navy vessels would likely occur as a result of the proposed action. Collisions with vessels would likely result in blunt trauma and lacerations leading to mortality, although some non-lethal interactions are also anticipated. The large majority of vessel strikes (about 10 lethal and 4 non-lethal per year) would affect the Central West Pacific DPS green sea turtle population. We expect a much smaller number of hawksbill and Central North Pacific DPS green turtle would be struck by Navy vessels as a result of the proposed action (i.e., up to one lethal and one non-lethal strike per year for each species or DPS). The majority of sea turtle vessel strikes as a result of the proposed action are expected to be juvenile turtles, although some adult green sea turtles (about two lethal and one non-lethal) from the Central West Pacific DPS could also be affected. It is extremely unlikely that a Navy vessel will strike a loggerhead or leatherback sea turtle as part of the proposed action. Thus, the effects of vessel strike on these species are considered discountable, and incidental take of these species by vessel strike is thus not reasonably certain to occur.

8.2.3 Fishes – Effects of Explosive Stressors

The effects of explosions on fish have been studied and reviewed by numerous authors (Keevin and Hempen 1997; O'Keeffe 1984; O'Keeffe and Young 1984; Popper et al. 2014). This section discusses the effects of explosive stressors from the proposed action on scalloped hammerhead sharks, oceanic whitetip sharks, and giant manta rays (see Section 5.1.2 for general discussion of explosives as a potential stressor).

Exposure Analysis

The general categories of the explosives that would be used in MITT activities, such as size and number of detonations, are described in the Table 23 (see Section 3.3). MITT activities that involve underwater detonations and explosive munitions typically occur in waters greater than 200 ft. in depth, and more than three NM from shore. However, most mine warfare and demolition activities would occur in shallow water close to shore. The number of torpedo testing activities (both explosive and non-explosive) planned under the proposed action can vary slightly from year to year; however, all other training and testing activities would remain consistent from year to year (Navy 2019e).

The Navy calculated ranges to effects for fish species based upon the sound exposure criteria discussed above in Section 2.2.7 of this biological opinion. Fish within the ranges shown in Table 83 would be predicted to receive the associated effect. Generally, explosives that belong to larger bins (with large NEWs) produce longer ranges within each effect category. However, some ranges vary depending upon a number of other factors (e.g., number of explosions in a single event, depth of the charge, etc.) (Navy 2019e).

The Navy will implement mitigation to avoid potential impacts on scalloped hammerhead sharks and giant manta rays in the MIRC during explosive mine neutralization activities involving Navy divers (see Section 3.6.2 *Mitigation Measures* for details). The Navy will also implement mitigation to avoid potential impacts from explosives on seafloor resources, which may help avoid potential impacts on species (e.g., hammerheads and manta rays) and life stages associated with shallow-water reef environments.

Below, we discuss the anticipated exposure of each ESA-listed fish species in the MITT Action Area to the effects from explosives. Contrary to the information available for cetaceans and sea turtles, we cannot quantitatively estimate the number of ESA-listed fish that could be impacted by explosives due to the lack of density and abundance information on these species in the action area. As such, our exposure analysis is a qualitative assessment of the likelihood of exposure to explosives based on available information including species' life histories and distribution, the proposed Navy activities that involve explosives (i.e., location, frequency, NEW), and the Navy's predicted range to effects as shown above (Table 83).

Table 83. Range to effects (mortality and injury) from explosives for fish species in the action area (Navy 2019e).

Bin	*Range to Effects (meters)*	
	Onset of Mortality	*Onset of Injury*
	SPL_{peak}	*SPL_{peak}*
E1 (0.25 lb. NEW)	50 (45–50)	122 (120–130)
E2 (0.5 lb. NEW)	63 (60–65)	156 (110–170)
E3 (2.5 lb. NEW)	108 (100–110)	276 (260–280)
E4 (5 lb. NEW)	141 (140–170)	381 (350–725)
E5 (10 lb. NEW)	175 (170–250)	433 (410–775)
E6 (20 lb. NEW)	218 (210–230)	526 (500–625)
E7 (60 lb. NEW)	330 (330–330)	856 (825–875)
E8 (100 lb. NEW)	375 (360–410)	920 (850–1,025)
E9 (250 lb. NEW)	490 (480–500)	1,025 (1,025–1,025)
E10 (500 lb. NEW)	617 (600–775)	1,388 (1,275–1,775)
E11 (650 lb. NEW)	785 (700–1,525)	2,111 (1,525–4,775)
E12 (1,000 lb. NEW)	770 (750–800)	1,781 (1,775–2,025)

Notes: SPL_{peak} = Peak sound pressure level, NEW = net explosive weight, lb. = pound(s). Range to effects represent modeled predictions in different areas and seasons within the action area. Each cell contains the estimated average, minimum and maximum range to the specified effect.

Scalloped Hammerhead Shark – Indo-West Pacific DPS

The Indo-West Pacific DPS of scalloped hammerhead shark may be exposed to sound and energy from explosives associated with training and testing activities throughout the Action Area. The scalloped hammerhead shark is primarily a shallow water, coastal species. Oceanic islands and seamounts represent important habitat for this species (Nalesso et al. 2019). Scalloped hammerheads have 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). The density of scalloped hammerhead sharks in the shallow, nearshore waters of the Action Area are not well understood but anecdotal evidence suggests Inner Apra Harbor and Sasa Bay may serve as nursery habitat for this species (NMFS 2015a). If these estuaries act as a nursery for scalloped hammerheads, juveniles may seasonally occur in substantial densities and it can also be reasonably expected that adult males and females would frequently move between Apra Harbor and nearshore areas outside the harbor.

Navy activities involving explosives would occur both in nearshore and offshore portions of the MITT Action Area. Detonations categorized by larger bins would occur in offshore areas, whereas some detonations from smaller bins could occur in bays and harbors. We anticipate that exposure of scalloped hammerheads to the effects of explosives would most likely occur in the nearshore areas given the species' preference for shallow, coastal environments. Exposure of hammerheads to offshore explosives is less likely considering the proposed number of offshore detonations, the large area over which such detonations would occur, and the anticipated low density of scalloped hammerheads in offshore areas. The Navy has proposed three nearshore underwater detonations (UNDET) sites: Outer Apra Harbor, which is within Apra Harbor itself; Agat Bay, which is south of Apra Harbor; and Piti, which is immediately north of Apra Harbor (Navy 2019e). For MITT Phase III, the Navy has proposed a total of 20 explosive charges per year for Mine Neutralization activities across these UNDET areas. The Navy has also proposed a total of 45 explosive charges per year for Underwater Demolition Qualification/ Certification activities across these UNDET areas. Explosives used in nearshore UNDET areas would have NEWs ranging from 5 to 20 lbs (i.e., bins E5 and E6). Four explosive neutralizers per year have also been proposed for Mine Neutralization involving ROVs in the Mariana littorals and Outer Apra Harbor. NEWs for this activity range from 2.5 to 5 lbs (i.e., bin E4). Underwater detonations would primarily occur during daytime hours when hammerheads are more likely to be closer to shore (Nalesso et al. 2019). Navy divers involved with underwater detonations would notify their supporting small boat or Range Safety Officer of hammerhead shark (any hammerhead species due to the difficulty of differentiating species) sightings within the mitigation zone or within their range of visibility. The Navy will cease detonations or fuse initiation until one of the following conditions has been met: 1) the animal is observed exiting the 500 yd or 1,000 yd mitigation zone, 2) the animal is thought to have exited the 500 yd or 1,000 yd mitigation zone based on a determination of its course, speed, and movement relative to the detonation site, or 3) the 500 yd or 1,000 yd mitigation zones (for Lookouts on small boats or aircraft), and the underwater detonation location (for divers) have been clear from any additional sightings for ten minutes during activities under positive control with aircraft that have fuel constraints, or 30 minutes during activities under positive control with aircraft that are not typically fuel constrained and during activities using time-delay firing devices (see Section 3.6.2, Table 36).

As mentioned above, density data for scalloped hammerheads 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. The Navy calculated ranges to effects for fish species from explosives (Table 83). Scalloped hammerhead sharks within these ranges would be predicted to receive the associated effect. While scalloped hammerhead sharks could be susceptible to effects (including mortality and injury) from any of the explosive bins listed in Table 83, as discussed above, most exposures are anticipated to occur around nearshore detonation sites where explosives in bins E4, E5 and E6 would primarily be used. Due to the dispersed, infrequent occurrence and short duration of explosive use, and the low density of scalloped hammerhead sharks anticipated to occur in offshore portions of the Action Area, it is unlikely that this species would be exposed to higher impact explosives (i.e., NEWs >20 lbs) that are proposed for use in offshore areas. Explosives that hammerheads are more likely to be exposed to in nearshore areas (i.e., < 20 lb NEW) produce smaller ranges to higher order effects such as mortality or injury compared to explosives in larger bin sizes, thus further reducing the potential that scalloped hammerhead sharks would incur impacts that would or could lead to fitness consequences. For a 20 lb. NEW the Navy predicts onset of mortality to occur within 218m and onset of injury to occur within 526m. The Navy's proposed continuation of procedural mitigation to avoid or reduce potential impacts on scalloped hammerhead sharks from explosive mine neutralization activities involving Navy divers should further reduce the number of exposures, as well as the impacts of those exposures, in nearshore areas.

Although unconfirmed, if Inner Apra Harbor and Sasa Bay act as a nursery for scalloped hammerhead sharks, neonates and juveniles may seasonally occur in substantial densities in these areas. For operational purposes, the Navy confines Apra Harbor underwater detonation specifically to the Outer Apra Harbor site (see Figure 25 in Section 4.4 above) (Navy 2019b). The entrances to Inner Apra Harbor and Sasa Bay (located northeast of Inner Apra Harbor) are over 1.5 NM from the end of the worst case mitigation range around the Outer Apra Harbor detonation site (Navy 2019d). Thus, we would not anticipate exposures to explosives to occur while hammerheads are within Inner Apra Harbor and Sasa Bay. However, if these locations serve as a nursery, it can be reasonably expected that adult females would frequently move from these areas through Outer Apra Harbor to nearshore areas outside the harbor. Such movements could result in scalloped hammerhead exposures to the effects from explosions within the Navy's Outer Apra Harbor UNDET. A Navy funded research project is currently underway to explore the use of environmental DNA in water samples to confirm the presence of scalloped hammerhead sharks at multiple locations within Apra Harbor and nearshore waters south of Orote peninsula.

Giant Manta Ray

Giant manta rays may be exposed to sound and energy from explosives associated with training and testing activities throughout the Action Area. We are not aware of any surveys for giant manta rays or species density information in the action area, but based on their life histories and

occurrence in other similar environments we would expect to find them there. Giant manta rays are commonly found offshore in oceanic waters, but are sometimes found in shallow waters during the day (Lawson et al. 2017; Miller and Klimovich 2017). Martin et al. (2016) analyzed aerial survey data from 1963-2012 of the insular coral reef ecosystem of Guam (including Apra Harbor). Giant manta rays were not observed over this time span, although surveyors did record 60 reef manta rays indicating that large rays were visible to aerial observers.

Navy activities involving explosives would occur both in nearshore and offshore portions of the MITT Action Area. Detonations categorized by larger bins would occur in offshore areas, whereas some detonations from smaller bins could occur in bays and harbors. Navy divers involved with underwater detonations would notify their supporting small boat or Range Safety Officer of manta ray (any manta ray species due to the difficulty of differentiating species) sightings at the detonation location. As discussed for hammerhead sharks above, the Navy will cease fuse initiations or detonations until one of the procedural mitigation conditions has been met (see Section 3.6.2, Table 36 for details), thus reducing the potential impacts from explosives on manta rays.

As mentioned above, density data for giant manta rays within the action area are not currently available; therefore, it is not possible to estimate the total number of individuals that may be affected by activities using explosives. The Navy calculated ranges to effects for fish species from explosives (Table 83). Giant manta rays within these ranges would be predicted to receive the associated effect. Due to the dispersed, infrequent occurrence and short duration of explosive use, and the anticipated low density of this species in the action area, giant manta ray exposures to explosives are expected to be rare. The Navy's proposed continuation of procedural mitigation to avoid or reduce potential impacts on giant manta rays from explosive mine neutralization activities involving Navy divers should further reduce the number of exposures, as well as the impacts of those exposures, in nearshore areas. Additionally, the majority of the explosives used in the action area can be categorized in, or below, bin E5 with occasional detonations of larger charge sizes (e.g., bins E6 and E8 through E12). These smaller bins produce smaller ranges to higher order effects such as mortality or injury compared to larger bin sizes, thus further reducing the likelihood that a giant manta ray would be within range to incur impacts that would or could lead to fitness consequences.

Oceanic Whitetip Shark

Oceanic whitetip sharks may be exposed to sound and energy from explosives associated with MITT activities throughout the Action Area. This highly migratory species is typically found in open ocean waters, the outer continental shelf, and around oceanic islands. Oceanic whitetip sharks spend much of their time at the surface, potentially increasing the risk of exposure to surface detonations.

Navy activities involving explosives would occur both in nearshore and offshore portions of the MITT Action Area. Detonations categorized by larger bins would occur in offshore areas,

whereas some detonations from smaller bins could occur in bays and harbors. From what we know about oceanic whitetip sharks, they primarily occur in open ocean habitats. We anticipate then, that if oceanic whitetip sharks are exposed to the effects of explosives, such exposure would likely occur in the offshore areas.

As mentioned above, density data for oceanic whitetip sharks within the action area are not currently available; therefore, it is not possible to estimate the total number of individuals that may be affected by activities using explosives. The Navy calculated ranges to effects for fish species from explosives (Table 83). Oceanic whitetip sharks within these ranges would be predicted to receive the associated effect (i.e., mortality or injury). Due to the dispersed, infrequent occurrence and short duration of offshore explosive use, and the anticipated low density of this species in the action area, oceanic whitetip exposures to explosives are expected to be rare. Additionally, the majority of the explosives used in the action area can be categorized in, or below, bin E5 with occasional detonations of larger charge sizes (e.g., bins E6 and E8 through E12). These smaller bins produce smaller ranges to higher order effects such as mortality or injury compared to larger bin sizes, thus further reducing the likelihood that an oceanic whitetip shark would be within range to incur impacts that would or could lead to fitness consequences.

Response Analysis

Barotrauma is injury due to a sudden difference in pressure between an air space inside the body and the surrounding water and tissues (Navy 2019e). Rapid compression followed by rapid expansion of airspaces can damage surrounding tissues and result in the rupture of the airspace itself. The blast wave from an in-water explosion is lethal to fish at close range, causing massive organ and tissue damage (Keevin and Hempen 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors, including fish size, body shape, depth, physical condition of the fish, geometry (angle) of exposure, cluster size of the explosives, season of the activity, and perhaps most importantly, the presence of a swim bladder (Keevin and Hempen 1997; Wright 1982; Yelverton and Richmond 1981; Yelverton et al. 1975). At the same distance from the source, larger fish are generally less susceptible to death or injury, elongated forms that are round in cross-section are less at risk than deep-bodied forms, and fish oriented sideways to the blast suffer the greatest impact (Edds-Walton and Finneran 2006; O'Keeffe 1984; O'Keeffe and Young 1984; Wiley et al. 1981; Yelverton et al. 1975). Fish species without a swim bladder, which includes the three ESA-listed species in the action area, are not thought capable of detecting sound pressure (Casper et al. 2012) and are considered much less susceptible to blast injury from explosives than species with a swim bladder (Gaspin 1975; Gaspin et al. 1976; Goertner et al. 1994).

While fish without a swim bladder (e.g., sharks and rays) are considered less susceptible to barotrauma, small airspaces, such as micro-bubbles that may be present in gill structures, could also be susceptible to oscillation when exposed to the rapid pressure increases caused by an explosion (Navy 2019e). Sudden very high pressures can also cause damage at tissue interfaces

due to the way pressure waves travel differently through tissues with different densities. Rapid pressure changes could cause mechanical damage to sensitive ear structures due to differential movements of the otolithic structures. Bleeding near otolithic structures was the most commonly observed injury in non-swim bladder fish exposed to a close explosive charge (Goertner et al. 1994). Rapidly oscillating pressure waves might rupture the kidney, liver, spleen, and sinus and cause venous hemorrhaging (Keevin and Hempen 1997).

There are no direct measurements of hearing loss in fish due to exposure to explosive sources (Navy 2019e). The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds, such as those produced by air guns. Hearing loss has not been demonstrated in any study of elasmobranchs exposed to other impulsive acoustic stressors such as air guns and pile driving, and PTS has not been shown to occur in any species of fish tested to date. Any hearing loss that occurs in fish may only be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al. 2014). As reviewed in Popper et al. (2014), fish without a swim bladder (e.g., sharks and rays), would likely be less susceptible to hearing loss (i.e., TTS), even at higher level exposures. 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 barotrauma, and therefore would be within the range of other injuries these fish 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 fish to acoustic stressors have been described in greater detail for other acoustics stressors on fish (see Section 8.1.3). Exposure to explosions could cause spikes in stress hormone levels, or alter a fish's natural behavioral patterns. Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle or avoidance responses. Fish have a higher probability of reacting when closer to an impulsive sound source (i.e., within tens of meters), and a decreasing probability of reaction at increasing distances (Popper et al. 2014). There are currently no behavioral thresholds for explosives established for fish. 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. Since sound generated from a detonation is brief, long-term effects on fish behavior are unlikely. Scalloped hammerheads, oceanic whitetips, and giant manta rays are all highly mobile animals and alternate habitat is likely available outside of the habitat area expected to be affected during each underwater detonation event. Sharks and rays that are temporarily displaced from their habitat through avoidance behavior would likely find adjacent habitat where forage, breeding habitat and refugia are available. While there are energetic costs associated with displacement, given the anticipated rare nature of ESA-listed fish

species exposures to explosive stressors, we do not expect such energetic costs to lead to long-term fitness consequences for individual sharks or rays.

There are no direct observations of masking in fish due to exposure to explosives. The *ANSI Sound Exposure Guideline* technical report (Popper et al. 2014) highlights a lack of data that exist for masking by explosives but suggests that the short duration, intermittent nature of explosions would result in very limited probability of any masking effects, and if masking were to occur it would only occur during the duration of the sound. Long periods of masking are unlikely from blast exposure for fish, 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 times, such as over the course of a day or consecutive days, fish 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 fish to sound and energy from underwater explosions over the course of a day or multiple days is not likely. Thus, most physiological stress and behavioral effects are expected to be temporary, of a short duration, and would return to normal quickly after cessation of the blast wave.

8.2.4 Coral – Effects of Explosives and Military Expended Materials

This section discusses the effects of impulsive acoustic stressors (i.e., explosives) and military expended materials on colonies of *Acropora globiceps*. As described previously in Sections 6.1.2 and 6.1.3 of this opinion, the available information regarding the distribution of *Acropora retusa* and *Seriatopora aculeata*, does not suggest these species are likely to occur near UNDETs or at-sea target sites. Therefore, we only analyze effects to *Acropora globiceps* in this section.

Coral reef survival and recovery may be affected by acute single blasts as well as chronic blasting over greater spatial and temporal scales. Fox and Caldwell (2006) examined coral reef recovery following acute single blasts and following chronic blasting. Rubble resulting from single blasts slowly stabilized, and craters filled in with surrounding coral and new colonies. After five years, coral cover within craters formed by single blasts no longer differed significantly from control plots. In contrast, extensively bombed areas showed no significant recovery over the six years of the study, despite adequate supply of coral larvae. After extensive blasting, resulting coral rubble may shift in ocean currents, abrading or burying new coral larvae, thereby slowing reef recovery (Fox and Caldwell 2006). The effects of dynamite or "blast" fishing may help provide some insight to the potential effects of detonation of live military ordnance in and around coral colonies. The shock waves from blast fishing explosions break the coral's calcium carbonate skeleton into small pieces. Once broken, the coral/algal symbiotic relationship is disrupted and the coral begins to lose nourishment and starts to die. Blast fishers typically target clumps of corals which often suffer mortality within approximately 1-2 meter radius from the blast (McManus 1997).

A study at a former U.S. Navy range at Vieques Island (Puerto Rico, U.S.), which is now the largest national wildlife refuge in the Caribbean, investigated the geomorphology and benthic assemblage structure to understand the status of the coral reefs (Reigl et al. 2008). In that study, investigators found no differences in living benthic coral reef cover or composition of coral assemblages inside and outside the bombing range or in comparison to reefs investigated on St. Croix. Reigl et al. (2008) concluded that this may indicate not that zero impacts occurred but rather that natural disturbances appear to have altered the coral communities drastically, thus obscuring military impacts. Effects of natural disturbances were severe at Vieques, outweighing impacts of past military activity, which were present but not quantitatively discernible at the scale of sampling. Disease and storms, rather than military expended ordnance, were seen to have taken the worst toll on corals at both Vieques and St. Croix (Reigl et al. 2008).

The Navy conducted annual nearshore marine resource surveys around FDM from 1999 through 2012 (except 2011). A 2013 report presented the findings of the calendar year 2012 survey and compared those findings with the previous 12 surveys (Smith et al. 2013). The report indicates that despite ongoing use by the DoD as a live and inert range, no significant impacts to the physical or biological environment were detected between 1999 and 2012. Direct ordnance impacts upon the submerged physical environment, which were clearly attributable to training activities, were detected in 2007, 2008, 2010, and 2012. Indirect impacts, such as ordnance that skipped or eroded off the island and rock and ordnance fragments blasted off the island were detected every year. The report indicated that very few areas of disturbance were detected, the size of any disturbed areas were generally less than 2 m^2, and substantial or complete recovery of these disturbed areas occurred within one year. Additionally, large numbers of one and two year old stony coral recruits were consistently observed, suggesting that coral recruitment is not a limiting factor around the island. The report also indicated that restricted access to FDM (because it is a DoD live and inert range) may have a conservation benefit to the reef ecosystem around the island, with marine resources at FDM comparable to or superior to those of any of the other islands within the Mariana Archipelago (Smith et al. 2013). A publication using these data (years 2005 to 2012) supported this conclusion, finding that restricted access around FDM has "resulted in a de-facto preserve effect" (Smith and Marx Jr. 2016).

Potential impacts to ESA-listed corals from impulsive acoustic stressors around Guam

The vast majority of training and testing activities around Guam that use explosives occur in areas greater than 12 nm from shore. The potential impacts of these activities to ESA-listed corals are not considered further in this opinion because ESA-listed corals do not occur in water depths that occur this far from shore. Similarly, the Agat Bay Mine Neutralization Site is located beyond 3 nm of Guam and we do not expect ESA-listed coral to occur at this location because of the water depths this far from shore. The Outer Apra Harbor UNDET site and Piti Point Mine Neutralization site are within less than one km of existing reef structures known to support coral growth (Figure 57). Explosives used at these sites are limited to 10 lbs NEW. Several surveys have been conducted within Apra Harbor (e.g., (Smith et al. 2009); (Starmer 2008)) and in only

three instances (Lybolt 2015; Schils et al. 2011), was *Acropora globiceps* observed. However, the species was observed near Kilo Wharf and Spanish Steps, located across Apra Harbor from the UNDET site. The species has not been documented within a close enough range to the Outer Apra Harbor UNDET site to be adversely affected by Navy activities at this site. All UNDET activity occurs at existing UNDET sites or locations that are monitored for presence of corals (including those that may contain *Acropora globiceps*). Effects from explosions and military expended materials at these locations are not reasonably expected to affect ESA-listed coral colonies due to the limited size of the explosives used, the distance between the sites and known locations of *Acropora globiceps*, as well as precautions taken by the Navy during these activities. For these reasons, it is extremely unlikely that adult *Acropora globiceps* colonies will be exposed to impulsive acoustic stressors around Guam and such effects are thus discountable.

FDM has been a target site for live-fire military exercises (ship-to-shore gunfire, aerial gunnery and bombing) since 1971 (Smith et al. 2013). While the majority of live and inert ordnance strikes the island and does not impact the nearshore marine environment, there are known instances where bombs have missed the island, or where munition fragments have entered the nearshore environment following an impact to the island (e.g., Smith and Marx Jr. 2016). Therefore, ESA-listed corals that are present in the nearshore environment around FDM could be impacted by Navy training at FDM. If an inert munition lands in the nearshore environment, either as a result of missing the island or ricocheting off the island, and contacts any ESA-listed coral colonies, it could cause injury or mortality of those colonies. Similarly, if an on-island explosion ejects munition and rock fragments into the surrounding waters, and these fragments contact an ESA-listed coral, it could also cause injury. Should munitions land in the nearshore environment and explode, the explosion would occur at or near the water's surface. While most explosive energy would be reflected upward, any coral in the vicinity would be exposed to pressure waves, which could cause injury or mortality.

As detailed in Table 84, FDM supports a full suite of munitions use, from the delivery of heavyweight explosive bombs dropped from fighter aircraft to small arms fire from helicopters. Up to 6,242 explosive bombs and 2,670 non-explosive bombs would be expended annually at FDM (8,912 total). Bombs range in size from 25 lbs to 2,000 lbs. Up to 42,000 small-caliber projectiles would be expended annually at FDM. Small-caliber projectiles are those projectiles that are 50 caliber and below. Small caliber projectiles will lose most of their energy upon contact with the water surface and are not expected to impact *Acropora globiceps* (which have typically been observed at FDM in waters between 15 and 25 m deep) with enough force to cause a measurable effect. Up to 17,350 explosive and 94,150 non-explosive projectiles would be expended annually. Medium caliber projectiles are those projectiles that are greater than 50 caliber, but less than 57mm. Up to 1,200 explosive, large-caliber projectiles and up to 1,800 non-explosive large-caliber projectiles would be expended annually. Large caliber includes 5-inch ship fired projectiles as well as mortars fired into the impact areas from the northern end of

FDM. Up to 85 explosive missiles would be expended and up to 2,000 explosive rockets would be expended annually at FDM.

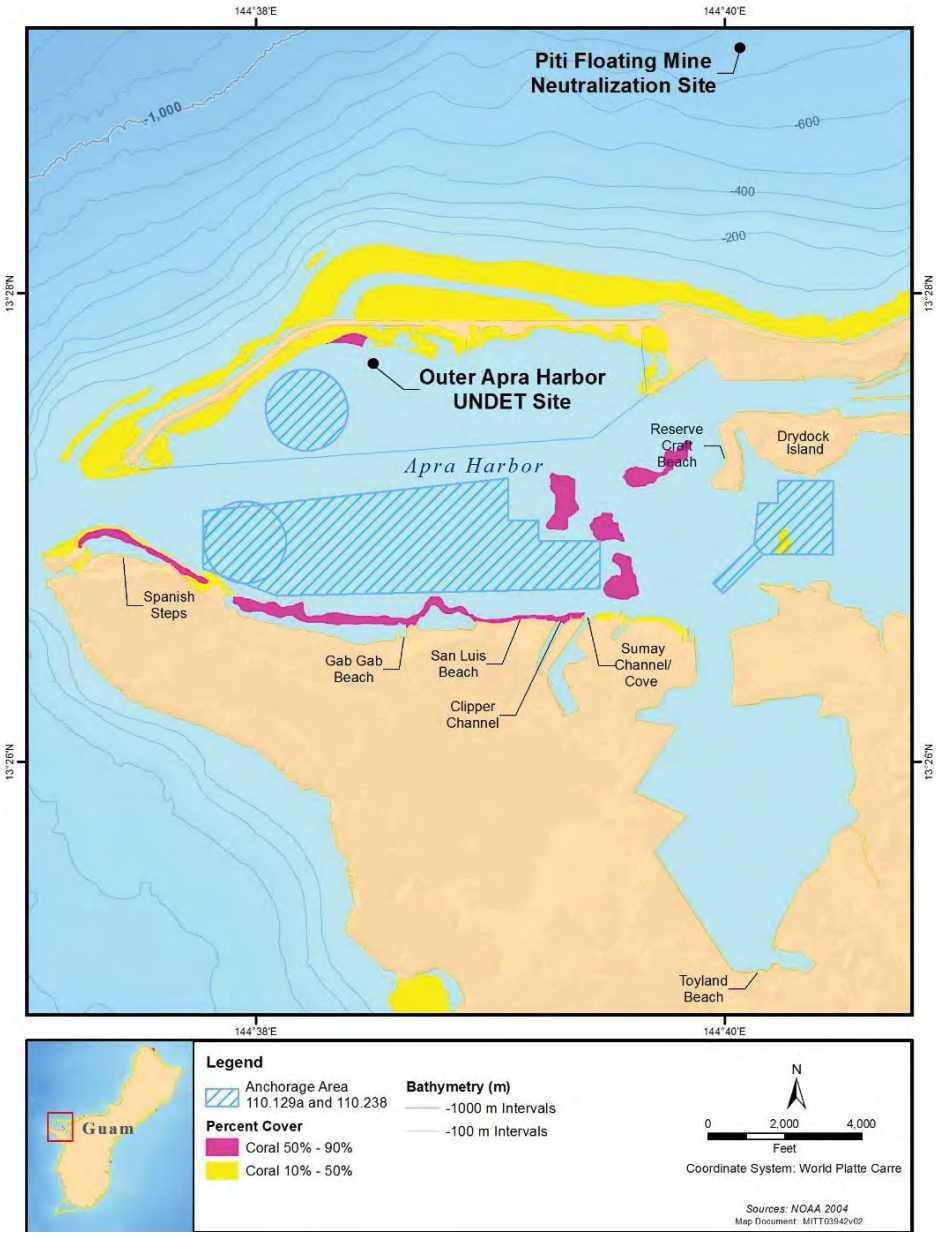


Figure 57. Underwater Detonation and Mine Neutralization Sites in and around Apra Harbor, Guam

Potential impacts to ESA-listed corals from impulsive acoustic stressors and expended materials around FDM

To estimate the potential impact resulting from physical disturbance, strike, and explosions, the Navy estimated the numerical quantity of explosive and non-explosive munition items, and munitions fragments which might enter the nearshore environment. While the maximum quantity of munitions to be used on FDM is known, they are intended to target FDM, not the surrounding waters. Thus, the number of munitions or fragments that enter the surrounding water, directly or indirectly, was estimated based on the percentage of those munition items which hit the island as intended and then enter the water due to ricochet or some other process, and the number of munitions that outright miss the island and land directly in the surrounding water. The Navy provided these estimates based on several data sources including range munition tracking information, after action reports, and Navy underwater dive studies of the waters surrounding FDM. For example, the Navy determined that at most, the number of non-explosive bombs which enter the near-shore environment is two percent of the non-explosive bombs expended and determined that the number of explosive bombs which enter the nearshore environment directly is at most one percent of the explosive bombs expended. More non-explosive bombs would be expected to enter the nearshore environment than explosive bombs because non-explosive bombs are much more likely to ricochet off the island and explosive bombs would only enter the nearshore environment as a result of missing FDM (Navy 2015a). Table 84 provides the Navy's estimates for the percent of each type of munition that are expected to impact nearshore habitat around FDM. Further detail on how these estimates were derived is available in a memo to the file (Navy 2015a).

For non-explosive munitions, munition fragments, and explosives with relatively small explosive weight (e.g., rockets and medium/large caliber projectiles) that may enter the nearshore environment, the Navy estimated an impact footprint based on the size of the munition or munition fragment. This information is provided in Table 84. Note that the rockets and medium/large caliber projectiles used at FDM have relatively small explosive weights and unlike bombs, the explosive effect of these munitions when detonated at the water's surface is not expected to impact coral (especially since ESA-listed corals at FDM were observed in 15-25 m depths).

For bombs with high explosives that may have greater impacts (see footnote in table), we also assessed the potential impact zone from a documented Navy observation of an underwater impact crater. During a 2010 survey, a fresh shallow crater was observed for the first time since 1999. The crater pit was 5 m across in its maximum dimension and the cratered portion of the seafloor was a maximum of 50 cm deeper than the surrounding sea floor. Water depth at the site was 12 m. Explosive Ordnance Disposal Detachment Marianas personnel judged that a bomb had detonated at the water surface to produce the disturbance. This event occurred in an area that was dominated by relatively barren bedrock. No corals or any other sessile benthic invertebrates or the remains thereof were observed in the crater/blast pit or within a distance of approximately

4 m from the edge of the crater. Past the 4 m perimeter, (approximately 9 m from the center of the impact site) sea floor cover by corals was estimated to be less than five percent. This observation suggests that any coral within a circular area with a diameter of 13 m (5m + 4m + 4m) could have been impacted, as coral beyond this range appear to be similar to undisturbed background locations. From this observation, we established an impact zone extending 6.5 m from the center of the crater, equating to an area of 132.73 m^2.

The impact zone is based on a single observation of a surface detonation in 12 m of water with approximately five percent coral cover. We recognize that the range to effects for mortality and injury will likely increase with a decrease in water depth (less than 12 m) and will likely decrease as water depth increases (greater than 12 m). We also recognize the explosive weight of the bomb that created the crater was not known. However, we assume it was a relatively large bomb to create a crater of that size 12 m below the water's surface. As such, smaller bombs would be expected to create a smaller blast-impact area. Also, the magnitude of effects may vary depending on bottom type and bottom features (boulders, shelves, etc.). For example, the percent of hard bottom versus soft bottom environments might influence the amount of refraction of sound pressure waves. Nevertheless, we consider this zone of effect to be representative of a typical scenario at FDM with an average depth and bottom type similar to the 12 meter depth observation.

Table 84 provides estimates of the total nearshore habitat area affected by munitions at FDM. The total area impacted by each munition type is the product of the number of items that are expected to fall in the nearshore environment by the impact area per item. As described above, with the exception of high explosive bombs, the area of habitat affected for all munition types is based on the physical footprint of that particular munition (i.e., from direct strike). For explosive bombs, the area of habitat affected is based the impact area from an explosion.

Table 84. Estimated area of nearshore habitat impacted by ordnance at Farallon de Medinilla.

Ordnance Items per the Proposed Action (FEIS/OEIS)	Number of Items Expended Annually	Percent of Items That Fall in the Nearshore Environment	Number of Items That Fall in Nearshore Environment	Impact Area Per Item (m^2)	Total Nearshore Habitat Area (m^2)
Bombs (HE)[1]	6,242	1	62	132.7300	8,285.01
Bombs (NEPM)	2,670	2	53	3.0044	160.43
Bomb debris (end plates)	6,242	50	3,121	0.073	227.61
Bomb Debris (ejecta)	6,242	50	3,121	0.073	227.61
Small-caliber projectiles	24,000	5	1,200	0.0056	6.72
Medium-caliber projectiles (HE)[2]	17,500	5	875	0.0104	9.10

Ordnance Items per the Proposed Action (FEIS/OEIS)	Number of Items Expended Annually	Percent of Items That Fall in the Nearshore Environment	Number of Items That Fall in Nearshore Environment	Impact Area Per Item (m^2)	Total Nearshore Habitat Area (m^2)
Medium-caliber projectiles (NEPM)	94,650	5	4,733	0.0104	49.22
Large-caliber projectiles (HE)[2]	4,200	5	210	0.188	39.40
Large-caliber projectiles (NEPM)	1,800	20	360	0.188	0.188
Missiles[3]	85	0	0	0	0
Rockets[2]	2,000	5	100	0.148	14.84
				Total Habitat Area Affected	9,020.13

[1]Bombs (High Explosives or HE) are the only ordnance anticipated to result in mortality of coral colonies.

[2]The rockets and medium/large caliber projectiles used at FDM have relatively small explosive weights and, therefore, the explosive effect of these munitions when detonated at the water's surface is not expected to have as large an impact on coral as bombs (especially since ESA-listed corals at FDM were observed in 15-25 m depths).

[3]Missiles are precision-guided and therefore will not fall in the nearshore environment.

NEPM – non-explosive practice munition

We estimate that the total area of nearshore habitat around FDM impacted annually is 9,020 square meters. The large majority of impacts are estimated to result from high explosive bombs that miss their intended on-shore target. We consider the estimated area of impact calculated above to be highly conservative because the crater our estimates are based on is the largest that has been observed in a decade of dive surveys. For example, Smith et al. (2013) indicated that the size of any disturbed areas were generally less than two square meters.

Exposure Analysis

Data from underwater surveys around FDM indicate that the most abundant coral species at FDM are *Pocillopora meandirna* and *Pocillopora eydouxi* (Smith et al. 2013). *Acropora globiceps* is the only confirmed ESA-listed coral that inhabits waters around FDM (Carilli et al. 2018; DoN 2005; Smith et al. 2013). During a 2017 FDM coral reef survey, only a single confirmed colony of *Acropora globiceps* was sighted in waters less than 20 m deep, indicating it is rare around FDM (Carilli et al. 2018). Carilli et al. (2018) did report an additional seven colonies of coral that could not be confirmed as *Acropora globiceps* in the same general area as the confirmed colony. Figure 58 below shows the potential impact areas on FDM and the only confirmed location of colonies of *Acropora globiceps*. Of note, the sighting location at the southeast section of FDM is not adjacent to impact zones for explosive munitions (Figure 58). Instead, it is immediately adjacent to a no fire zone with an inert ordnance only zone (Impact Area 3) to the southwest.

The use of live ordnance is limited to Impact Area 2 and 3. Impact Area 3 supports inert ordnance with high explosive ordnance authorized on a case-by-case basis. The majority of the

in-water habitat adjacent to Impact Area 3 (i.e., on the east or west side of the island) is composed of unconsolidated and uncolonized course sediment and rubble with zero percent live coral cover. However, this region is also the closest to the confirmed colony of *Acropora globiceps*. If ordnance were to impact nearshore habitat on the east side of FDM in the northern portion of this zone, it is possible that *Acropora globiceps* colonies could be impacted. Impact Area 3 is also the location where we expect the majority of the nearshore impacts to occur because this area is a narrower land mass, as compared to Impact Areas 1 and 2, leaving pilots less margin for error. Adjacent to Impact Area 2, most of the live coral cover is less than five percent, but a portion is composed of coral reef with live coral cover ranging from greater than 25 percent to greater than 50 percent.

Figure 58. Location of *Acropora globiceps* in Relation to FDM Impact Areas.

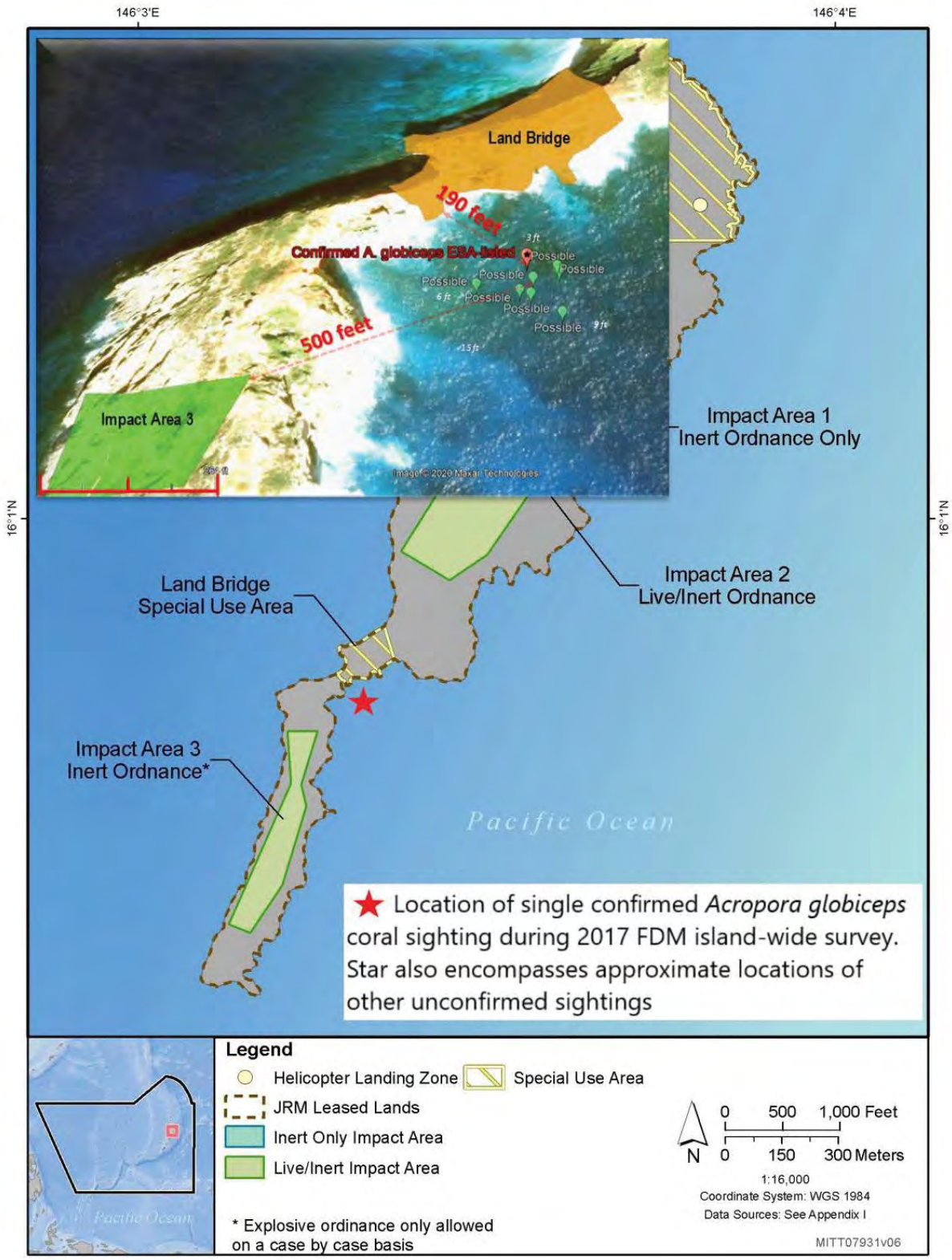


Figure 59. Confirmed and Suspected Locations of *Acropora globiceps* in Relation to FDM Impact Areas 2 and 3.

Similar to other areas in the Indo-Pacific, the coral community around FDM is characterized by high species diversity (79 FR 53852), with a low proportion of ESA-listed species (i.e., *Acropora globiceps*) mingled with many non-listed corals (DoN 2005). *Acropora globiceps* is considered one of the more common ESA-listed corals in the Indo-Pacific, but Veron (2014) reported that the species only occurred at 3.2 percent of the 2,984 dive sites sampled throughout the Indo-Pacific region (included American Samoa, Mariana Islands, and Hawaii). At each site where it was sampled, based on an abundance rating on a scale of one (low) to five (high), this species had a mean abundance rating of 1.95. Based on this semi-quantitative system, the species' abundance was characterized as "uncommon" (Veron 2014). Similarly, while the species was field identified during most of the FDM surveys from 1999 to 2012, survey data from FDM indicate that *Acropora globiceps* is relatively rare compared to many of the other 80 coral species identified in the area (DoN 2005). The rarity of this species, and the information presented above regarding the potential locations where the majority of nearshore habitat impacts are expected to occur (i.e., in areas with very low percent live coral cover), suggests that while a small portion of the nearshore habitat around FDM may contain *Acropora globiceps* colonies, the majority of the area impacted by Navy activities each year would not contain this species.

As noted in the final listing rule, Indo-Pacific reef-building coral species are generally difficult to identify, even by experts, because of: 1) the high biodiversity of reef-building corals, 2) the high morphological plasticity in many reef-building coral species, and 3) the different methods used for species identification (NMFS 2014, 79 FR 53852). For example, 13 of the 15 ESA-listed Indo-Pacific coral species, including *Acropora globiceps*, have a moderate or high level of species identification difficulty (Fenner and Burdick 2016). Thus, even if experts can be hired to survey and monitor Action Area sites, the species-level data is likely to be confounded by species identification uncertainty.

Furthermore, coral reef communities are highly dynamic whether humans are present or not, with species presence/absence, colony density, colony size and morphology, and other factors varying over small spatial scales (e.g., a few meters separate forereef and backreef habitats, which can have radically different coral communities) and small temporal scales (e.g., seasonal and annual cycles of natural disturbance, like storms and predation events, can wipe out a species or community in a particular area, followed by species recovery). The spatial and temporal variability in coral habitat and species abundance is described in detail in the final rule's Corals and Coral Reefs section ((Barlow 2016), 79 FR 53852). Even with this confirmed sighting of *Acropora globiceps* and confirmation of the other potential colonies, over time, any changes in species distribution and abundance caused by the proposed action are likely to be confounded by natural variability.

As noted above, only a single confirmed colony of *Acropora globiceps* was sighted around FDM in a 2017 survey in a location immediately adjacent to a no fire zone and in close proximity to an inert ordnance zone. However, for the reasons discussed above, other colonies of this species may either currently be present around FDM or could colonize other nearshore areas around the

island in the reasonably foreseeable future. In addition, as noted in the Navy's BA, for MITT Phase III there would be an overall increase in the number of training events and munitions used on FDM, which may increase impacts on coralline habitats in nearshore waters surrounding FDM (Navy 2019e). Based on the limited available information, and in consideration of the uncertainty regarding the location and distribution of this species, we believe that Navy activities involving the use of explosives and other expended materials around FDM are likely to adversely affect *Acropora globiceps* through injury and mortality.

Due to the lack of data on the abundance and distribution of ESA-listed corals in the action area, and other uncertainties regarding the effects of this stressor, it is not possible to quantify the impacts of Navy explosives and other expended materials on *Acropora globiceps* in terms of numbers of individuals or colonies adversely affected. Though we are unable to provide a quantitative estimate of the number of *Acropora globiceps* colonies impacted by Navy activities at FDM, we can qualitatively assess the likelihood that impacts will occur to areas of nearshore habitat that may be suitable for *Acropora globiceps*. From above, we estimated that the total area of nearshore habitat around FDM impacted annually from direct strike and explosive effects is 9,020 square meters. However, only a portion of this total impacted area would likely be suitable as habitat for *Acropora globiceps.* If additional colonies of *Acropora globiceps* occur around FDM (i.e., besides those recently identified), we would expect to find them in habitats with existing live coral cover and at depths less than 30 m. Thus, we find that *Acropora globiceps* may be exposed to the adverse effects from Navy activities involving the use of explosives and other expended materials on FDM within the subset of the total estimated area (i.e., 9,020 square meters) impacted annually which contains live coral cover and is in water less than 30 m deep.

Response Analysis

Any *Acropora globiceps* colonies that occur in the area of habitat impacted will be subject to a range of effects. Even slight physical contact with a coral colony by an ordnance or ordnance fragment can crush and/or scrape off living polyps and interconnecting soft tissues in the area of contact, causing injured or dead tissue in the disturbed area. Additionally, direct trauma and mortality of corals may occur due to the rapid pressure changes associated with an explosion. Though most invertebrates lack air cavities that would respond to pressure waves, which typically causes the most damage in fish or marine mammals, a blast in the vicinity of hard corals (i.e., *Acropora globiceps*) could cause direct impact to coral polyps leading to coral colony death, or fragmentation and siltation of the corals.

The tissue thickness of *Acropora* species is 1 to 2 mm thick, considerably thinner than many coral species, which allows them to grow quicker than many other species (Loya et al. 2001). Therefore, injured *Acropora globiceps* colonies (i.e., colonies that are not completely destroyed) would likely be able to bud and develop new polyps to replace those lost in the injury. Fragmentation of the skeleton could result in the development of new, but genetically identical colonies. Bothwell (1981) reports that several *Acropora* species successfully colonize through fragmentation and translocation of fragments by storm-driven waves. Broken pieces may

develop into new colonies over time, but re-growth of damaged tissue and skeleton has energetic costs that could slow other physiological processes such as reproduction. Fragmentation may lead to a large number of asexually-produced, genetically identical colonies, commonly resulting in a population made up of more asexually-produced colonies than sexually-produced colonies (Hughes 1984).

Potential impacts from detonations on ESA-listed coral eggs, sperm, and larvae

Acropora globiceps broadcast spawn where fertilization and early embryonic development occurs (see Section 6.2.13). The eggs, sperm, and larval stage of *Acropora globiceps* could remain in the water column for extended periods. Each individual polyp of an *Acropora* coral can produce 16 eggs and concentrations of sperm can be as high as one million per milliliter of seawater during spawning. Fertilized eggs develop into planula larvae within five days in *Acropora* species but these larvae can also remain in the water column over 200 days before settling. It is reasonable to assume in-water detonations occurring around FDM, at the Piti Point Floating Mine Neutralization site, the Agat Bay Mine Neutralization site, and the Outer Apra Harbor UNDET site could affect eggs, sperm, or planula larvae of *Acropora globiceps* (or other ESA-listed coral species) if their presence coincided with an explosion. Life stages subjected to the shearing forces of turbulent shockwaves from underwater detonations could be deformed, die, or experience a decreased likelihood of fertilization. Shock waves in the waters around explosions may reflect off of hard surfaces and the surface of the water, magnifying the exposure of nearby reefs. However, as described above, the reproductive biology of *Acropora globiceps*, and other coral species, results in prolific larval production and high natural mortality from a combination of factors including predation and dispersal to areas within the ocean without appropriate settlement habitat (e.g., deeper or colder water, unsuitable substrate). Any anthropogenic mortality from the Navy's proposed action is likely to be infinitesimally small by comparison and biologically insignificant to the reproduction of corals (NMFS 2017c). Additionally, of the 19 threats to coral identified in the 2011 status review report of the 82 candidate coral species petitioned under the ESA (Brainard et al. 2011) and the top nine threats to coral analyzed in the final rule (79 FR 53851), none include mortality of larvae by physical contact such as cavitation or explosives, or acoustic effects. While detonations may result in the mortality of the developmental stages of *Acropora globiceps* (and other ESA-listed coral species), it likely would have an insignificant effect on the reproductive potential for an individual colony of this species. The reproductive biology of coral species results in prolific larval production and high natural mortality from a combination of factors, including predation and dispersal to areas within the ocean without appropriate settlement habitat (e.g., deeper water, colder water, inappropriate substrate).

9 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 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 of the ESA.

During this consultation, we searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area. We conducted electronic searches of business journals, trade journals, and newspapers using *First Search*, Google, and other electronic search engines. Most of the Action Area includes federal military reserves or is outside of territorial waters of the U.S., which would preclude the possibility of many future state, tribal, or local actions that would not require some form of federal funding or authorization. We did not find any information about non-Federal actions other than what has already been described in the *Environmental Baseline* (Section 7), most of which we expect would continue in the future. An increase in these activities could similarly increase their effects on ESA-listed species and for some, an increase in the future is considered reasonably certain to occur. In particular, threats associated with climate change, coastal development and pollution, marine debris, fisheries bycatch, vessel strike, and ocean noise are likely to continue in the future. For many of the 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 populations of ESA-listed species. Thus, this opinion assumes effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the *Species and Designated Critical that May be Affected* (Section 6) and *Environmental Baseline* (Section 7).

10 INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the Effects of the Action (Section 8) to the Environmental Baseline (Section 7) and the Cumulative Effects (Section 9) to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated critical habitat as a whole for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 6).

We measure risks to individuals of ESA-listed species using changes in the individual's "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect ESA-listed species exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the overall reproduction, numbers, or distribution of the populations those individuals represent or the species those populations comprise. As a result, if we conclude that listed animals are not likely to experience reductions in their fitness, we would conclude our assessment. If, however, we conclude that listed animals are likely to experience reductions in their fitness, we would assess the consequences of those fitness reductions for the population or populations the individuals in an Action Area represent.

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. Depending on the severity and duration, temporary impacts to hearing (i.e., TTS) also have the potential to impact the fitness of individual animals, and potentially, populations. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like cetaceans and sea turtles. Of critical importance in discussion on the potential consequences of disturbance is the health of the individual animals disturbed, and the trajectory of the population those individuals comprise. The consequences of disturbance, particularly repeated disturbance, would be more significant if the affected animal were already in poor condition as such animals would be less likely to compensate for additional energy expenditures or lost foraging or reproductive opportunities. However, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life

stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion. Where stressors were determined to have insignificant or discountable effects to certain or all species earlier in this opinion, those stressors will not cause adverse effects to individuals of those species as such are not anticipated to cause a population or species level effect.

10.1 Cetaceans

In the *Species Likely to be Adversely Affected* sections above (Sections 6.2.1 through 6.2.5) we describe the current status to cetacean populations and the ongoing threats to their survival and recovery. In the *Environmental Baseline* (Section 7) and *Cumulative Effects* (Section 9) we identify past activities, and those expected to generally continue into the foreseeable future within the action area, that may impact ESA-listed cetaceans. In this section, we assess the likely consequences of the anticipated effects from our effects analysis (Section 8) to the cetaceans that have been exposed, the populations those individuals represent, and the species those populations comprise. Our conclusions for each ESA-listed cetacean species (or DPS) in the action area are discussed in Sections 10.1.1 through 10.1.5 below.

We determined that a range of impacts including TTS, behavioral responses, and stress are likely to occur due to exposure to Navy acoustic stressors during training and testing events. While this opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities and sensitivities of some ESA-listed cetaceans; how these animals use sounds as environmental cues; how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of species; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals; and the circumstances that could produce outcomes that have adverse consequences for individuals and populations of exposed species. Based on the best available information, we expect most exposures and potential responses of ESA-listed cetaceans to Navy acoustic stressors to have little effect on the exposed animals. As is evident from the controlled exposure experiments and opportunistic research on the effects of sonar presented previously, responses are expected to be short-term, with the animal returning to normal behavior patterns shortly after the exposure is over (e.g., (Goldbogen et al. 2013); Silve et al. 2015). However, Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. As described in further detail in Section 8.2.1, we would expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, occur in locations where the

animals are conducting critical activities, and when the animal affected is in a compromised state.

10.1.1 Blue Whale

The blue whale was originally listed as endangered on December 2, 1970 under the Endangered Species Preservation Act (35 FR 18319), the predecessor to the ESA. The current abundance trend for blue whales rangewide, including within the MITT Action Area, is not well understood. However, recent evidence indicates that some blue whale populations in the North Pacific may be increasing (Monnahan et al. 2015). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007). The best abundance estimate for blue whales in the action area is 133 animals (Calambokidis and Barlow 2013).

Assuming that the Navy conducts the maximum authorized activity levels of MITT activities involving sonars and other transducers, we estimate that in any given year during the seven-year period (August 2020 through August 2027), blue whales could potentially experience up to four instances of take in the form of behavioral harassment and up to 20 instances of take in the form of TTS. We assume that any physiological response (e.g., TTS) or significant behavioral response to acoustic stressors is also associated with a stress response. Based on the estimated abundance in the action area (133, from Bradford et al. 2017), only a relatively small proportion of blue whales in the action area would likely experience behavioral harassment or TTS from acoustic stressors in a given year. No blue whale impacts from explosives are anticipated in the action area. The blue whales that are exposed to acoustic stressors would be exposed periodically or episodically over certain months or seasons from military activities in the MITT Action Area. Given the nature of testing and training as described above, these periodic or episodic exposure and behavioral response scenarios, including TTS and elevated stress levels, allow sufficient time to return to baseline conditions and resumption of normal behavioral activities such as feeding and breeding. As described previously in our effects analysis of this opinion, the available scientific information does not provide evidence that such exposures to acoustic stressors from Navy training and testing activities will impact the fitness of any individuals of this species. Thus, the estimates of exposures to training and testing exercises that would result in behavioral responses and hearing impairment annually would not be expected to appreciably reduce the likelihood of the survival and recovery of blue whales in the wild by reducing the reproduction, numbers, or distribution of this species. Based on the best available information on the exposure of cetaceans to sonar and explosives, and as detailed in Section 8.2.1, no injury (PTS or non-auditory injury) or mortality of blue whales is anticipated to occur from exposure to these stressors.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, recent evidence indicates that some blue whale populations in the North Pacific may be increasing, and the Eastern North Pacific population has likely reached carrying capacity (Monnahan et al. 2015). Because these activities are the same or very similar to those proposed in the action area for the next seven years and the

reasonably foreseeable future, this suggests blue whales are likely resilient to the impacts incurred from MITT activities.

Some of the primary anthropogenic threats to the survival and recovery of blue whales have been whaling, anthropogenic noise, and vessel strikes. The threat of whaling to blue whales has been eliminated. As described previously in our effects analysis of this opinion (Sections 8.1.1 and 8.2.1), anthropogenic noise associated with MITT activities would not likely have long-term effects on the fitness of any individuals of this species and vessel strike of blue whales is extremely unlikely to occur (i.e., discountable) from Navy training and testing activities.

In summary, the impacts expected to occur and affect blue whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of the blue whale population in the Pacific Ocean. Because we do not anticipate impacts to the blue whale population in the Pacific Ocean, we also do not anticipate appreciable reductions in overall reproduction, numbers, or distribution of the blue whale population rangewide. For this reason, the effects of the proposed action are not expected to appreciably diminish the likelihood of survival and recovery of blue whales in the wild.

10.1.2 Fin Whale

The fin whale was originally listed as endangered on December 2, 1970, under the Endangered Species Preservation Act (35 FR 18319), the predecessor to the ESA. Global population estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters inclusive of the Action Area. Within the action area, fin whale abundance is estimated to be approximately 154 individuals (Bradford et al. 2017).

Assuming that the Navy conducts the maximum authorized activity levels of MITT activities involving sonars and other transducers, we estimate that in any given year during the seven-year period (August 2020 through August 2027), fin whales could potentially experience up to five instances of take in the form of behavioral harassment and up to 20 instances of take in the form of TTS. We assume that any physiological response (e.g., TTS) or significant behavioral response to acoustic stressors is also associated with a stress response. Based on the estimated abundance in the action area (154, from Bradford et al. 2017), only a relatively small proportion of fin whales in the action area would likely experience behavioral harassment or TTS from acoustic stressors in a given year. No fin whale impacts from explosives are anticipated in the action area. The fin whales that are exposed to acoustic stressors would be exposed periodically or episodically over certain months or seasons from military activities in the MITT Action Area. Given the nature of testing and training as described above, these periodic or episodic exposure and behavioral response scenarios, including TTS and elevated stress levels, allow sufficient time to return to baseline conditions and resumption of normal behavioral activities such as feeding and breeding. As described previously in our effects analysis of this opinion (Sections 8.1.1 and 8.2.1), the available scientific information does not provide evidence that such exposures to acoustic stressors from Navy training and testing activities will impact the fitness of

any individuals of this species. Thus, the estimates of exposures to training and testing exercises that would result in behavioral responses and hearing impairment annually would not be expected to appreciably reduce the likelihood of the survival and recovery of fin whales in the wild by reducing the reproduction, numbers, or distribution of this species. Based on the best available information on the exposure of cetaceans to sonar and explosives, and as detailed in Section 8.2.1, no injury (PTS or non-auditory injury) or mortality of fin whales is anticipated to occur from exposure to these stressors.

The 2010 fin whale recovery plan defines three recovery populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to MITT activities. As described previously (Sections 8.1.1 and 8.2.1), anthropogenic noise associated with MITT activities would not likely impact the fitness of any individuals of this species and vessel strike of a fin whales is extremely unlikely to occur (i.e., discountable) from Navy training and testing activities. Downlisting criteria for fin whales includes the maintenance of at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a ten percent chance of becoming endangered in 20 years. To our knowledge a population viability analysis has not been conducted on fin whale recovery populations.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, as discussed above, the North Pacific fin whale population has already exceeded the downlisting criteria for mature individuals. Because these past activities are the same or very similar to those proposed in the action area for the next seven years and into the reasonably foreseeable future, this suggests fin whales are likely resilient to the impacts incurred from MITT activities.

In summary, the impacts expected to occur and affect fin whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of the fin whale population in the Pacific Ocean. Because we do not anticipate impacts to the fin whale population in the Pacific Ocean, we also do not anticipate appreciable reductions in overall reproduction, numbers, or distribution of the fin whale population rangewide. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of fin whales in the wild.

10.1.3 Humpback Whale – Western North Pacific DPS

The humpback whale was originally listed (range-wide) as endangered on December 2, 1970 under the Endangered Species Preservation Act (35 FR 18319), the predecessor to the ESA. In

2016, NMFS revised the ESA listing for the humpback whale to identify 14 DPSs, including the endangered Western North Pacific DPS which occurs in the action area. The current abundance of the Western North Pacific DPS is an estimated 1,107, with a minimum population size estimate of 865 (Muto et al. 2019). A population growth rate is currently unavailable for this DPS. Within the action area, the abundance of humpbacks are estimated to be approximately 938 animals based on extrapolated data from a regional survey off the Phillipines (Acebes et al. 2007). There is no recovery plan specific to humpback whales from the Western North Pacific DPS. The 1991 humpback whale recovery plan (for the previous range-wide listing) does not outline specific downlisting and delisting criteria. The recovery plan lists several threats known or suspected of impacting humpback whale recovery including subsistence hunting, commercial fishing stressors, habitat degradation, loss of prey species, ship collision, and acoustic disturbance. Of these, acoustic disturbance is most relevant to MITT activities, although we also address the likelihood of effects to prey and of vessel strike above (Section 8.1.1).

Assuming that the Navy conducts the maximum authorized levels of MITT activities involving sonars and other transducers, we estimate that in any given year during the seven-year period (August 2020 through August 2027), Western North Pacific DPS humpback whales could potentially experience up to 91 instances of take in the form of behavioral harassment and up to 677 instances of take in the form of TTS. Of these takes, we estimated 20 behavioral harassment and 150 TTS takes annually would be of mother-calf pairs (i.e., 10 and 75 with calves; 10 and 75 with mothers). We also anticipate up to one incident of PTS take of a mother-calf pair (i.e., two takes) approximately every nine years as a result of the proposed action. We assume that any physiological response (e.g., TTS) or significant behavioral response to acoustic stressors is also associated with a stress response. Similarly, at maximum authorized levels of MITT activities involving explosives, humpback whales could potentially experience up to six instances of take in the form of behavioral harassment and up to three instances of take in the form of TTS.

The presence of humpback whales from winter through early spring in the nearshore waters of Saipan has been documented since 2007 (Fulling et al. 2011; Hill et al. 2017; Hill et al. 2018; Hill et al. 2016a; Hill et al. 2020a; Hill et al. 2020b; Hill et al. 2019; Klinck et al. 2016; Oleson et al. 2015; Uyeyama 2014). These sightings have been associated with mother/calf pairs, documentation of male singing, and behaviors associated with breeding areas for this species. Breeding areas are known as locations of mother/calf bonding and feeding and serve to allow the mother to reduce the expenditure of energy during a period of drastically reduced feeding (Bejder et al. 2019). Disruptions to the mother/calf bonding can create stress and potentially impact the growth of the calf and reduce energy stores of the lactating mother. Regions of low energy expenditure and areas which allow mothers to rest have been shown to be essential for the health of lactating females.

Anthropogenic noise can have negative impacts on the energy expenditure of the mother and calf and on calf fitness, which can affect their migration potential (Bejder et al. 2019; Cartwright and Sullivan 2009; Craig et al. 2014). An increase in the disturbance level from noise-generating

human activities, including Navy sonar and vessel traffic, may increase the risk of mother–calf pair separation, reducing the time available for suckling, or require that louder contact calls are made which, in turn increases the possibility of detection.

While individual adult whales are likely more capable of avoiding sonar, mothers and neonate calves may not be as mobile. The mothers rarely feed while on the breeding grounds, and calves spend a large portion of the time feeding to gain weight for the eventual migration to the feeding grounds. Mothers use this time to lower unnecessary energy expenditures to be able to nurse the calf during the migration. Disruption of feeding of the calf can have consequences for the survivability of the calf during migration and include lack of nutrition, decreased performance, and predation.

Videsen et al. (2017) suggests that the small active space of the weak calls between mother and calf is very sensitive to increases in ambient noise from human encroachment, thereby increasing the risk of mother/calf separation. Separation of the mother and calf can expose the mother to harassment by the males seeking breeding opportunities, increasing the energy expenditure of the mother, and can result in continued separation from the calf. The separation of the mother and calf could also result in the calf having greater exposure to the potential risk of ship strike in and around Saipan anchorage area.

Few behavioral response studies have specifically looked at the response of mother-calf pairs to anthropogenic noise, with most studies targeting individual adult animals. Information regarding the responses of mother-calf pairs to anthropogenic noise is unclear at best. McCauley et al. (2003; cited by (Dunlop et al. 2018)) found that resting humpback mother-calf pairs did show avoidance responses to seismic airguns at relatively low received levels (129 dB re 1 $\mu Pa^2 \cdot s$). There are several other studies which indicate the response is low and similar to adult response behavior (as cited in (Dunlop et al. 2018)).

(Sivle et al. 2015) reported that during a severity response study that a tagged female (with calf) exposed to naval sonar exhibited avoidance behavior and the calf was seen moving with the mother. This severity was considered to have the potential to affect vital rates in humpback whales (Sivle et al. 2015). This study was conducted on the feeding grounds and was indicative of a calf with much greater swimming abilities after having already made the migration from the calving grounds.

Sonar exposure of adult whales (non-calf animals) will likely result in changes in behavior, TTS exposure, and physiological stress responses. The behavior of males on the breeding ground is not expected to change dramatically given the increases in testosterone indicative of whales on the breeding grounds (Vu et al. 2015) and the desire to find a mate. Humpback whale's reactions to MFAS have recently been reported from the Pacific Missile Range Facility on Niihau, Hawaii. During February 2018, six satellite tags were deployed on humpback whales prior to the Submarine Commanders Course, and five of the six whales were exposed to MFAS during the event (Henderson et al. 2019b; Martin et al. 2019a). Four of the five tagged whales (assumed

males) showed some bouts of extreme movements (e.g., rapid bursts and high turning angles); only one of the five tagged whales had a statistically significant change in behavior relative to MFAS. At the onset of MFAS (max received level of 158 dB re 1μPa), this tagged whale was traveling north onto the range, changed direction and began traveling south, while executing a series of steep dives of increasing depths. Received levels estimated at the bottom of each dive indicated that levels were lower during these deeper dives, possibly in an attempt to reduce received levels while moving away from the source. Once MFAS stopped, dive behavior returned to normal and the whale returned to its original northbound travel (Martin et al. 2019a) (Henderson et al. 2019b).

Based on the estimated abundance in the action area (938, from (Acebes et al. 2007)), humpback whales in the action area would likely experience less than one (0.83) behavioral harassment or TTS take, on average, from acoustic stressors in a given year (although some individuals could be exposed more than once in a particular year and some not at all). However, since the density of humpback whales in the shallow water breeding/calving grounds from December through April is significantly greater in comparison to other areas, humpback whale mother-calf pairs within the GMAs would likely experience higher take levels. Based on our effects analysis, and assuming the maximum level of MF1 sonar use (i.e., 20 hours) proposed in the GMAs from December through April, we estimate that mother-calf pairs would experience about four TTS and one behavioral harassment take per year on the breeding/calving grounds. There is also the potential for multiple exposures of the same individual on successive days or over a five day event period. We also anticipate a very small number (i.e., about one exposure of a mother-calf pair every nine years) of exposures would result in PTS of humpback whale mother-calf pairs. Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to effect aspects of the affected animal's life functions that do not overlap in time and space with the proposed action. Although we cannot quantify the magnitude of PTS, given the Navy's proposed procedural mitigation measures for active sonar, the short PTS range to effects (i.e., 65 meters) for low-frequency cetaceans from MF1 sonar (Navy 2018d), and the anticipated vessel speed, incidents of PTS are expected to be of relatively low magnitude. As discussed above (Section 8.2.1), this level of acoustic disturbance would occur during a particularly sensitive period in the humpback whale's life history when both the mother and the calf are more vulnerable to both natural and anthropogenic stressors. Based on our analysis, we believe that some very small number of humpback whale mother-calf pairs could experience fitness consequences as a result of MF1 sonar use in the GMAs, and the synergistic effects of this acoustic stressor combined with other stressors during this vulnerable life stage. Next, we discuss the effects of acoustic stressors resulting from the proposed action on humpback whales exposed outside of the breeding/calving grounds.

While we anticipate some humpback whales in the action area could experience more than one behavioral disruption per year, individuals would likely be exposed periodically, and based on

the available literature such infrequent behavioral disturbances are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015; NAS 2017; New et al. 2014; Southall et al. 2007; Villegas-Amtmann et al. 2015). Therefore, with the exception of mother-calf humpback whale pairs within the GMAs (as discussed above), we do not expect this level of exposure to impact the fitness of individual humpback whales. Further, we anticipate that most instances of TTS will be of minimum severity and short duration. This conclusion is based on literature indicating that even following relatively prolonged periods of sound exposure resulting in TTS, recovery occurs quickly (Finneran 2015). The brief amount of time cetaceans are expected to experience TTS is unlikely to significantly impair their ability to communicate, forage, or breed and is not expected to have long-term fitness consequences for the individuals affected (with the exception of mother-calf humpback whale pairs within the GMAs, as discussed above). Additionally, in general, we do not anticipate whales will experience long duration or repeat exposures within a short period of time due to the species' wide ranging life history and that long duration (i.e., more than one day) Navy activities also occur over large geographic areas (i.e., both the animal and the activity are moving within the action area, most likely not in the same direction). This decreases the likelihood that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity. Although there is an increased chance that TTS resulting from explosives would affect frequencies utilized by animals for acoustic cues (as compared to TTS from sonar), the Navy's quantitative model predicts very few instances of humpback whale TTS from explosives. Since it is unlikely that an individual whale would experience TTS from Navy explosives on multiple occasions, adverse effects on acoustic cues resulting from such exposures would likely be limited in scope and duration for individual whales.

In summary, we do not anticipate that instances of behavioral harassment or TTS from Navy activities involving sonar (and other transducers) and explosives would result in long-term fitness consequences to individual humpback whales (excluding mother-calf pairs within the GMAs) in the action area. Due to their elevated vulnerability on the breeding/calving grounds, increased potential for multiple exposures over a short period of time, likely reduced avoidance capability, synergistic effects of other stressors, and other reasons discussed above, we anticipate that a very small number of humpback whale mother-calf pairs would likely experience fitness consequences from TTS and behavioral harassment as a result of the Navy's use of MF1 sonar in the GMAs. Fitness consequences could also result from PTS, although we expect PTS would be of relatively low magnitude, and would occur very rarely (approximately one exposure of a mother-calf pair PTS [i.e., two takes] every nine years) as a result of the proposed action. Based on our analysis, we expect that the number of humpback whale mother-calf pairs that experience fitness consequences annually as a result of the proposed action would be an extremely small proportion (<< 1 percent) of the Western North Pacific DPS (currently estimated at 1,107 whales). Further, our effects analysis did not estimate any mortality or serious injury of humpback whales as a result of the proposed action. As such, the impacts expected to occur and affect humpback whales in the action area are not anticipated to result in appreciable reductions

in the overall reproduction, numbers, or distribution of the Western North Pacific DPS. For this reason, we conclude that the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of Western North Pacific DPS humpback whales in the wild.

10.1.4 Sei Whale

The sei whale was originally listed as endangered on December 2, 1970 under the Endangered Species Preservation Act (35 FR 18319), the predecessor to the ESA. The most recent abundance estimate for sei whales in the North Pacific Ocean is 29,632 animals (IWC 2016; Thomas et al. 2016). Abundance data for this species in the action area is estimated to be approximately 166 individuals (Fulling et al. 2011). Specific to sei whales in the action area, data precludes assessing population trends for this species.

Assuming that the Navy conducts the maximum authorized levels of MITT activities involving sonars and other transducers, we estimate that in any given year during the seven-year period (August 2020 through August 2027), sei whales could potentially experience up to 17 instances of take in the form of behavioral harassment and up to 135 instances of take in the form of TTS. For purposes of our effects analysis, we assume that any physiological response (e.g., TTS) or significant behavioral response to acoustic stressors is also associated with a stress response. Similarly, at maximum authorized levels of MITT activities involving explosives, sei whales could potentially experience up to two instances of take in the form of behavioral harassment and up to one instance of take in the form of TTS. Based on the estimated abundance in the action area [166, from (Fulling et al. 2011)], each sei whale in the action area would likely experience, on average, about one behavioral harassment or TTS from acoustic stressors in a given year, although some individuals could be exposed more than once in a particular year, while others may not be exposed at all.

The sei whales that are exposed to acoustic stressors would be exposed periodically or episodically over certain months or seasons from military activities in the MITT Action Area. Given the nature of testing and training as described above, these periodic or episodic exposure and behavioral response scenarios, including TTS and elevated stress levels, allow sufficient time to return to baseline conditions and resumption of normal behavioral activities such as feeding and breeding. Because a wider frequency band would be affected, there is a greater likelihood that TTS hearing impairment resulting from explosives (as compared to TTS from sonar) would affect frequencies utilized by sei whales for acoustic cues. However, the Navy's quantitative model predicts only one exposure per year resulting in TTS from explosives. In addition, as described previously in our effects analysis of this opinion, the available scientific information does not provide evidence that such exposures to acoustic stressors from Navy training and testing activities will impact the fitness of individual sei whales. Thus, the estimates of exposures to training and testing exercises that would result in behavioral responses and hearing impairment annually would not be expected to appreciably reduce the likelihood of the survival and recovery of sei whales in the wild by reducing the reproduction, numbers, or

distribution of this species. Based on the best available information on the exposure of cetaceans to sonar and explosives, and as detailed in Section 8.2.1, no injury (PTS or non-auditory injury) or mortality of sei is anticipated to occur from exposure to these stressors.

The 2011 sei whale recovery plan defines three recovery populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to MITT activities. As described previously in our effects analysis of this opinion (Sections 8.1.1 and 8.2.1), anthropogenic noise associated with MITT activities would not likely impact the fitness of any individuals of this species and vessel strike of a sei whale is extremely unlikely to occur (i.e., discountable) from Navy training and testing activities. Downlisting criteria for fin whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a ten percent chance of becoming endangered in 20 years. To our knowledge, a population viability analysis has not been conducted for the North Pacific population of sei whales.

In summary, the impacts expected to occur and affect sei whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of the sei whale population in the North Pacific Ocean. Because we do not anticipate impacts to the sei whale population in the North Pacific Ocean, we also do not anticipate appreciable reductions in overall reproduction, numbers, or distribution of the sei whale population rangewide. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of sei whales in the wild.

10.1.5 Sperm Whale

The sperm whale was originally listed as endangered on December 2, 1970 under the Endangered Species Preservation Act (35 FR 18319), the predecessor to the ESA. Sperm whales are the most abundant of all the large whale species and recent estimates indicate a global population of between 300,000 and 450,000 individuals (Whitehead 2009). In the Northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. Abundance estimates for the Action Area estimate the population to be approximately 705 animals (Fulling et al. 2011).

Assuming that the Navy conducts the maximum authorized activity levels of MITT activities involving sonars and other transducers, we estimate that in any given year during the seven-year period (August 2020 through August 2027), sperm whales could potentially experience up to 192 instances of take in the form of behavioral harassment and up to 11 instances of take in the form

of TTS. For purposes of our effects analysis, we assume that any physiological response (e.g., TTS) or significant behavioral response to acoustic stressors is also associated with a stress response. Based on the estimated abundance in the action area (e.g. 705), only a relatively small proportion of sperm whales in the action area would likely experience behavioral harassment or TTS from acoustic stressors in a given year. No sperm whale impacts from explosives are anticipated as a result of the proposed action.

The sperm whales that are exposed to acoustic stressors would be exposed periodically or episodically over certain months or seasons from military activities in the MITT Action Area. Given the nature of testing and training as described above, these periodic or episodic exposure and behavioral response scenarios, including TTS and elevated stress levels, allow sufficient time to return to baseline conditions and resumption of normal behavioral activities such as feeding and breeding. As described previously in our effects analysis of this opinion (Sections 8.1.1 and 8.2.1), the available scientific information does not provide evidence that such exposures to acoustic stressors from Navy training and testing activities will impact the fitness of any individuals of this species. Thus, the estimates of exposures to training and testing exercises that would result in behavioral responses and hearing impairment annually 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 this species. Based on the best available information on the exposure of cetaceans to sonar and explosives, and as detailed in Section 8.2.1, no injury (PTS or non-auditory injury) or mortality of sperm whales is anticipated to occur from exposure to these stressors.

Although the historical threat of whaling to the worldwide population is no longer a primary threat, sperm whales continue to face several other threats. Current potential threats affecting the recovery of sperm whale populations include vessel strikes, entanglement in fishing gear, anthropogenic noise, exposure to contaminants, climate change, and marine debris. Of these, anthropogenic noise and vessel strike are relevant to MITT activities. As described previously (Sections 8.1.1 and 8.2.1), anthropogenic noise associated with MITT activities would not likely impact the fitness of any individuals of this species and vessel strike of a sperm whales is extremely unlikely to occur (i.e., discountable) from Navy training and testing activities.

In summary, the impacts expected to occur and affect sperm whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of the sperm whale population in the Northeast Pacific Ocean. Because we do not anticipate impacts to the sperm whale population in the Northeast Pacific Ocean, we also do not anticipate appreciable reductions in overall reproduction, numbers, or distribution of the sperm whale population rangewide. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of sperm whales in the wild.

10.2 Sea Turtles

In the *Species Likely to be Adversely Affected* sections above (Sections 6.2.6 through 6.2.9) we describe the current status to sea turtle populations and the ongoing threats to their survival and

recovery. In the *Environmental Baseline* (Section 7) and *Cumulative Effects* (Section 9) we identify past activities, and those expected to generally continue into the foreseeable future within the action area, that may impact ESA-listed sea turtles. In this section, we assess the likely consequences of the anticipated effects from our effects analysis (Section 8) to the sea turtles that have been exposed, the populations those individuals represent, and the species those populations comprise.

The major anthropogenic stressors that contributed to the sharp decline of sea turtle populations in the past include coastal development, direct harvest, commercial fisheries bycatch, and marine debris. Most sea turtle populations have undergone significant to severe reductions caused by a combination of commercial and subsistence harvesting (of both eggs and sea turtles), loss or degradation of beach nesting habitats, and high levels of bycatch in commercial fisheries worldwide. While sea turtle populations are still at risk, efforts made over the past few decades to reduce the impact of these threats have slowed the rate of decline for many sea turtle populations, and increasing abundance trends have now been reported for several populations (or nesting sites) of ESA-listed sea turtles. Bycatch mitigation measures, including turtle excluder devices and gear restrictions, have reduced the incidental take of sea turtles in many U.S. commercial fisheries. Harvest of sea turtles has been greatly reduced in some locations, though it still occurs in other parts of the world, including many areas in the Pacific Ocean. Increased conservation awareness at the international scale has led to greater global protection of sea turtles. All six ESA-listed sea turtles are currently listed in CITES Appendix I and many countries now have regulations banning turtle harvest and export. Among the countries that still allow directed take of sea turtles, harvest has decreased by more than 60 percent over the past three decades (Humber et al. 2014). It is likely that some current threats to sea turtles will increase in the future. These include global climate change, marine debris (i.e., plastics), and habitat degradation. However, it is difficult to predict the magnitude of these threats in the future or their impact on sea turtle populations.

The activities conducted as part of the Navy's proposed action introduce a variety of stressors into the Action Area that are expected to result in adverse effects to the following ESA-listed sea turtles: Central West Pacific DPS green, East Indian-West Pacific DPS green, Central North Pacific green, leatherback, hawksbill, and North Pacific DPS loggerhead. The primary impacts on sea turtles resulting from the Navy's proposed action are from explosives and vessel strikes. Other potential stressors analyzed, including various acoustic sources (e.g., sonar, vessel and aircraft noise, and weapons noise), ingestion of expended materials, entanglement, energy stressors, and physical disturbance, are not likely to adversely affect sea turtles given the 1) characteristics of these stressors, 2) frequency and expanse of the Action Area they would be dispersed throughout, and 3) densities of sea turtles, and likelihood that they would co-occur with Navy activities and encounter them. While this biological opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities of sea turtles, such as how they use sound to

perceive and respond to environmental cues, and how temporary changes to their acoustic soundscape could affect the normal physiology and behavioral ecology of these species.

Vessel strikes and encounters with underwater detonations (explosives) are expected to result in sublethal and lethal adverse effects to sea turtles. Those that are killed by vessel strike and removed from the population would result in decreased reproductive rates, while those that sustain non-lethal injuries could result in fitness consequences during the time it takes to fully recover, or have longer lasting impacts if permanently harmed. There is an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, and occur in locations where sea turtles are conducting critical activities at the time of exposure.

The Navy's quantitative analysis, using a maximum year of training and testing activities, estimates that no sea turtle mortalities or non-auditory injuries would occur as a result of MITT activities using explosives. A small number of green sea turtles are expected to be exposed to levels of explosive sound and energy that could cause PTS and TTS (Navy 2019e). The quantitative analysis predicts that no hawksbill, leatherback, or loggerhead sea turtles are likely to be exposed to levels of explosive sound and energy that could cause PTS, or TTS during training and testing activities under the proposed action. The Navy will implement mitigation measures (described in Section 3.6.2) which include several Lookout scenarios with large exclusion zones to minimize both the number of individuals exposed to explosives and the impacts of explosives on sea turtles that are exposed.

Hearing impairment and significant behavioral disruption from harassment could have adverse effects, but given the duration of exposures, these impacts are expected to be short-term and a sea turtle's hearing is expected to return back to normal after some healing duration. There is no evidence that TTS results in energetic effects to individual sea turtles or would be likely to significantly reduce the viability of the population these individuals represent. Given that sea turtles are not thought to rely on acoustic cues for most important life functions, it is anticipated that TTS would not result in long-term fitness consequences to individuals or the populations to which they belong. A permanent loss of hearing (PTS) could cause some type of compensations from other senses, which could result in an energetic cost to individual turtles. However, we are not aware of any scientific studies addressing the energetic costs of PTS in sea turtles.

Behavioral responses of sea turtles to explosives could include startle reactions, disruption of feeding, disruption of migration, changes in respiration, alteration of swim speed, alteration of swim direction, and area avoidance. Any such responses are expected to be temporary in nature, with the animal resuming normal behaviors shortly after the exposure. To result in significant fitness consequences, we would have to assume that an individual turtle detects and responds to the acoustic source, and that it could not compensate for lost feeding opportunities by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since foraging habitat would still be available in the environment following the cessation of acoustic exposure. Similarly, we expect temporary disruptions of migration and swim speed or direction to be

inconsequential because exposed turtles could resume these behaviors almost immediately following cessation of the sound exposure. Further, these sorts of behavioral disruptions may be similar to natural disruptions such those resulting from predator avoidance, or fluctuations in oceanographic conditions. Therefore, behavioral responses of sea turtles to acoustic stressors are unlikely to lead to fitness consequences or have long-term implications for the population.

Our conclusions for each ESA-listed sea turtle species (or DPS) in the action area are discussed below.

10.2.1 Green Sea Turtle

The green sea turtle was listed under the ESA on July 28, 1978. On April 6, 2016, NMFS listed eleven DPSs of green sea turtles, including three that, based on our effects analysis, are likely to be adversely affect by the proposed action: Central West Pacific; Central North Pacific; and East Indian-West Pacific. Once abundant in tropical and subtropical waters, green sea turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches, and directed hunting of turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net and trawl fisheries kill thousands of green sea turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

Central West Pacific

The Central West Pacific DPS green sea turtles is listed under the ESA as endangered. This DPS is spatially bounded by the Asian continent to the west and north, the Solomon Islands to the south, the Marshall Islands to the east, and Palau to the west. There are 51 known nesting sites for the Central West Pacific DPS, with an estimated 6,518 nesting females (Seminoff et al. 2015). The largest nesting site for this DPS is in the Federated States of Micronesia which accounts for an estimated 22 percent of all nests within the DPS (Seminoff et al. 2015). Saipan, Tinian and Rota comprise an estimated six percent of the nesting sites for the Central West Pacific DPS overall (Summers et al. 2018b).

The Central West Pacific DPS is impacted by incidental bycatch in fishing gear, predation of eggs by ghost crabs and rats, and directed harvest of eggs and nesting females for human consumption. Historically, intentional harvest of eggs from nesting beaches was one of the principal causes for decline, and this practice continues today in many locations. This DPS has a small number of nesting females and a widespread geographic range. These factors, coupled with the threats facing the DPS and the unknown status of many nesting sites makes the DPS as a whole vulnerable to future perturbations. However, a long-term population time series analysis for the Central West Pacific DPS from Ogasawara, Japan reported a positive annual growth rate

of 6.8 percent (Seminoff et al. 2015), and Martin et al. (2016) reported a similar growth rate (7.0 percent) for green sea turtles around Guam. In addition, CNMI nesting data suggest an annual increase in nesting females of 7.4 percent per year (11 percent without accounting for poaching rates) (Summers et al. 2018b). This population increase is despite the Navy conducting training and testing activities around Guam and throughout the MITT Action Area for decades. Martin et al. (2016) suggested that protections in the region may be working to recover turtle populations and noted that the observed increase in green sea turtles in Guam is consistent with the historical shift from extraction to conservation protection.

Information was not available to estimate the abundance or density of each green sea turtle DPS in most portions of the Action Area. Therefore, sufficient information was not available to quantitatively assign green sea turtle take to specific DPSs. As discussed in Section 6.2.6, the vast majority of the green sea turtles that occur in the action area are likely from the Central West Pacific DPS. The majority of the Action Area overlaps with the nesting range of this DPS and the limited genetic testing that has occurred in the action area (in nearshore areas around CNMI) indicates that most green sea turtles are from this DPS. Therefore, the majority of green sea turtles that would be adversely affected by the Navy's activities would likely be from the Central West Pacific DPS.

Based on our *Effects Analysis* (Section 8.2.2), we estimate there would be 14 vessel strikes (10 lethal and 4 non-lethal) of Central West Pacific DPS green sea turtles annually as a result of the proposed action. The mortality of any individual sea turtle from a population represents the loss of 100 percent of that individual's reproductive potential. Since some of the turtles killed by vessel strike could be females, the proposed action may also result in a greater reduction in reproduction of this species. Loss of a sexually mature female will have immediate effects on recruitment, while lost reproductive potential from mortality of a juvenile (or subadult) female might not be realized for several years. For long-lived species, such as sea turtles, mortality of juveniles or subadults affects future reproductive potential and could have effects on a population for decades.

The majority of these vessel strikes are expected to be juvenile or subadult turtles, although, based on size data provided in Summers et al. (2018a), an estimated three (two lethal; one non-lethal) adult green sea turtles (i.e., (SCL ≥ 81 cm) from the Central West Pacific DPS could also be affected annually. Eight of the lethal strikes (out of 10 total estimated) from this DPS are expected to juvenile or subadult turtles. It is reasonable to assume that, due to natural (e.g., shark predation, disease) and anthropogenic (e.g., bycatch) mortality, not all of the juvenile and subadult turtles killed by vessel strike would have otherwise survived to the age of maturity. Annual survivorship of juvenile and subadult green sea turtles as reported in the literature typically ranges from about 0.85 to 0.90 (Seminoff et al. 2015). Conservatively assuming a 90 percent annual survivorship and a 20 year period to reach maturity (i.e., from 15 to 35 years old), we estimate that about 12 percent (i.e., 0.9^{20}) of juvenile and subadult turtles killed by vessel strike would have otherwise survived to the age of maturity. Applying the 12 percent survival

rate to the estimated eight neritic juvenile/subadults killed (0.12 * 8), yields (after rounding) one turtle that would have survived to maturity had they not been killed by a vessel strike. Adding this to the estimated two adults killed by vessel strike, we get a total of three adults (two current and one future) removed annually from the population as a result of vessel strike. Even if we conservatively assume that all three adult mortalities are females, this represents an annual loss of less than 0.05 percent of the estimated 6,518 nesting females (Seminoff et al. 2015) for the Central West Pacific DPS. We do not consider this to be an appreciable reduction in the numbers of female green sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. Thus, the anticipated proportional loss of current and future reproductive potential is relatively small, and would have a negligible effect on the recent increasing trend in nesting abundance as 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 this population of Central West Pacific DPS green sea turtles, we do not expect this level of mortality to appreciably reduce the likelihood of survival and recovery of this population.

Up to four Central West Pacific DPS green sea turtles are also expected to experience sub-lethal effects per year from a vessel strike as a result of the proposed action. As discussed above for lethal strikes, most of these (i.e., over 80 percent) would be juveniles or subadults. Injury from a vessel strike may result in temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect the level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population.

From our *Effects Analysis* (Section 8.2.2), we also anticipate Central West Pacific DPS green sea turtles would experience behavioral responses, TTS, and PTS from exposure to explosives used during MITT activities. Based on the Navy's quantitative model, we expect an annual average of three exposures resulting in PTS, six resulting in TTS, and 2,381 resulting in a short-term behavioral response. Although some of these exposures could be to other green turtle DPSs, we expect the large majority would be from the Central West Pacific DPS. Based on the Navy's quantitative model, and assuming up to 95 percent of the green turtle takes (from Table 82) could be from this DPS, we expect an annual average of up to three exposures resulting in PTS, six resulting in TTS, and 2,262 resulting in a short-term behavioral response. Similar to vessel strike exposures, we expect that most Central West Pacific DPS exposures to explosives (i.e., over 80 percent) would be with juvenile or subadults turtles. We anticipate that some individual green sea turtles could be exposed to explosives from the proposed action on multiple occasions within a given year or over their lifetime.

Although PTS could result in fitness impacts on individual sea turtles, such effects are only predicted to occur in a very small number (three PTS per year) of green sea turtles. While we have no information to indicate the magnitude of the fitness impacts that may result, given the small number of individuals affected it is unlikely to have an appreciable impact at the population level for this DPS. As discussed previously, 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, although a relatively large proportion of the adult green sea turtle population in the MITT Action Area could experience a behavioral response from explosives, such responses are expected to be short-term, and are not anticipated to result in reduced fitness of individual turtles. Since Central West Pacific DPS green turtles nest within the action area (Frey et al. 2013; Kittinger et al. 2013), behavioral responses to explosives could potentially impact nearshore reproductive behavior. However, since most MITT activities involving explosives occur offshore, and a relatively small proportion (about six percent) of Central West Pacific DPS nests occur in the action area (Frey et al. 2013; Kittinger et al. 2013; Summers et al. 2018b), behavioral responses to explosives are not expected to appreciably impact nesting success of the DPS as a whole. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either insignificant or discountable.

In summary, we anticipate an extremely small number of individual Central West Pacific DPS green sea turtles, relative to the population size, would be killed or injured as a result of vessel strike or experience PTS or TTS as a result of explosives. While a larger number of turtles from this DPS would experience minor, short-term behavioral harassment due to explosives, we do not anticipate such effects would increase the risk of mortality or injury, nor would they result in the reduced fitness of individual turtles. The impacts expected to occur and affect Central West Pacific DPS green sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of Central West Pacific DPS green sea turtles in the wild.

Central North Pacific

The Central North Pacific DPS green sea turtle is listed under the ESA as threatened. There are 12 known nesting sites for the Central North Pacific DPS, with an estimated 3,846 nesting females (Seminoff et al. 2015). There is little diversity in nesting areas and this DPS has a relatively low level of genetic diversity and stock sub-structuring. The largest nesting site for this DPS is French Frigate Shoals, Hawaii which accounts for an estimated 96 percent of all nests within the DPS (Seminoff et al. 2015). Based on surveys conducted since 1973, nesting abundance at French Frigate Shoals has increased at a rate of 4.8 percent annually. There are no nesting sites for this DPS within the action area.

Incidental bycatch in fishing gear, ingestion of marine debris, and the loss of nesting habitat due to sea level rise are current threats to the Central North Pacific DPS. In addition to the general threats most sea turtle populations face, Central North Pacific DPS green sea turtles exhibit high rates of fibropapillomatosis disease, which has been shown to result in reduced individual fitness and survival.

Information was not available to estimate the abundance or density of each green sea turtle DPS in most portions of the Action Area. Therefore, sufficient information is not available to quantitatively assign green sea turtle take to specific DPSs. As discussed in Section 6.2.6, the

vast majority of the green sea turtles that occur in the action area are likely from the Central West Pacific DPS. We expect a relatively small number of green sea turtles from the Central North Pacific DPS to experience adverse effects as a result of the proposed action. Limited genetic sampling has indicated that approximately three percent of green sea turtles foraging in nearshore areas around CNMI are likely from this DPS. Since we do not know the proportion of green sea turtles from this DPS in other portions of the Action Area, for purposes of our integration and synthesis analysis we conservatively assume up to five percent of the anticipated take from the proposed action could be from the Central North Pacific DPS.

Based on our *Effects Analysis* (Section 8.2.3), we estimate there would be up to two vessel strikes (one lethal and one non-lethal) of Central North Pacific DPS green sea turtles annually under the proposed action. The mortality of any individual sea turtle from a population represents the loss of 100 percent of that individual's reproductive potential. Since some of the turtles killed by vessel strike could be females, the proposed action may also result in a reduction in reproduction of this species. For long-lived species, such as sea turtles, mortality of juveniles or subadults affects future reproductive potential and could have effects on a population for decades. All vessel strikes of Central North Pacific DPS green sea turtles are expected to be with juvenile or subadult turtles. It is reasonable to assume that, due to natural (e.g., shark predation, disease) and anthropogenic (e.g., bycatch) mortality, not all of the juvenile and subadult turtles killed by vessel strike would have otherwise survived to the age of maturity. Annual survivorship of juvenile and subadult green sea turtles, as reported in the literature, typically ranges from about 0.85 to 0.90 (Seminoff et al. 2015). Conservatively assuming a 90 percent annual survivorship and a 20 year period to reach maturity (i.e., from 15 to 35 years old), we estimate that about 12 percent (i.e., 0.9^{20}) of juvenile and subadult turtles killed by vessel strike would have otherwise survived to the age of maturity. Applying the 12 percent survival rate to the estimated one neritic juvenile/subadult killed (0.12 * 7), yields (after rounding) 0.12 turtles per year that would have survived to maturity had it not been killed by a vessel strike.

Even if we conservatively assume that all vessel strikes of this DPS are females, this represents an annual loss of less than 0.1 percent of the estimated 3,846 nesting females (Seminoff et al. 2015) for the Central North Pacific DPS. We do not consider this to be an appreciable reduction in the numbers of female green sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. The anticipated proportional loss of current and future reproductive potential is relatively small 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 this population of Central North Pacific DPS green sea turtles, we do not expect this level of mortality to impact the survival or recovery of this population.

Up to one Central North Pacific DPS green sea turtle per year may also experience sub-lethal effects from a vessel strike as a result of the proposed action. As discussed above for lethal strikes, most of these would be juveniles or subadults. Injury from a vessel strike may result in

temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect the level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population.

From our *Effects Analysis* (Section 8.2.3), we also anticipate Central North Pacific DPS green sea turtles would experience behavioral responses, TTS, and PTS from exposure to explosives used during MITT activities. Based on the Navy's quantitative model, and assuming up to five percent of the green turtle takes (from Table 82) could be from this DPS, we expect an annual average of 0.15 exposures resulting in PTS, 0.30 resulting in TTS, and 120 resulting in a short-term behavioral response. All exposures of Central North Pacific DPS green sea turtles to explosives are expected to be with juvenile or subadult turtles. We anticipate that some individual green sea turtles could be exposed to explosives from the proposed action on multiple occasions within a given year or over their lifetime.

Although PTS could result in fitness impacts on individual sea turtles, such effects are only predicted to occur in a very small number (i.e., about one PTS every six years, on average) of green sea turtles. While we have no information to indicate that relative magnitude of the fitness impacts in terms of individual survival and reproduction, given the very small number affected it is unlikely to have an appreciable impact at the population level for this DPS. As discussed previously, we have no information to suggest that TTS in sea turtles would result in fitness (Frey et al. 2013; Kittinger et al. 2013), behavioral responses to explosives would have no impact on Central North Pacific DPS green sea turtle reproductive behavior or nesting success. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

In summary, we anticipate an extremely small number of individual Central North Pacific DPS green sea turtles, relative to the population size, would be killed or injured as a result of vessel strike or experience PTS or TTS as a result of explosives. While a larger number of turtles from this DPS would experience minor, short-term behavioral responses due to explosives, we do not anticipate such effects would increase the risk of mortality or injury, nor would they result in the reduced fitness of individual turtles. The impacts expected to occur and affect Central North Pacific DPS green sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of Central North Pacific DPS green sea turtles in the wild.

East Indian-West Pacific

The East Indian-West Pacific DPS green sea turtle is listed under the ESA as threatened. This DPS is found in the Indian Ocean from Southeast Asia through Western Australia. There are 58 known nesting sites for the East Indian-West Pacific DPS, with an estimated 77,009 nesting females (Seminoff et al. 2015). The largest nesting site for this DPS is the Wellesley Island Group, Australia which accounts for an estimated 32 percent of all nests within the DPS

(Seminoff et al. 2015). There are no estimates of population growth for the East Indian-West Pacific DPS. In general, there is a decrease in nesting females throughout the DPS, with the exception of Malaysia and the Philippines showing an increase, attributed to successful conservation efforts. There are no nesting sites for this DPS within the action area.

Genetic studies conducted on over one-third of the rookeries in the East Indian-West Pacific DPS reveal a complex population structure. Sixteen regional genetic stocks have been identified, with a few common and widespread haplotypes throughout the region. Rare or unique haplotypes are present at most rookeries (Seminoff et al. 2015).

The East Indian-West Pacific DPS is relatively large, though it has been reduced from historic levels due to overutilization for commercial and subsistence purposes. Green turtles and their eggs are still harvested for consumption in some areas. Other current threats to the DPS include mortality from incidental bycatch, and predation by feral pigs, dogs and foxes.

Information was not available to estimate the abundance or density of each green sea turtle DPS in most portions of the Action Area. Therefore, sufficient information is not available to quantitatively assign most green sea turtle take to specific DPSs. As discussed in Section 6.2.6, the vast majority of the green sea turtles that occur in the action area are likely from the Central West Pacific DPS. A relatively small number of green sea turtles from the East Indian-West Pacific DPS would also likely experience adverse effects from MITT activities occurring in offshore areas. Since we do not know the proportion of green sea turtles from this DPS, for purposes of our integration and synthesis analysis we conservatively assume up to five percent of the anticipated take of green sea turtles in offshore areas could be from the East Indian-West Pacific DPS.

Based on our *Effects Analysis* (Section 8.2.2), we estimate there would be vessel strikes of sea turtles in the nearshore portions of the Action Area. Since green sea turtles from the East Indian-West Pacific DPS are expected to be found only in the offshore portions of the Action Area, we determined that the likelihood of a Navy vessel strike of an East Indian-West Pacific DPS green turtle is so low as to be considered discountable. Also from our *Effects Analysis* above, we anticipate East Indian-West Pacific DPS green sea turtles would experience behavioral responses from exposure to explosives used during MITT activities. PTS and TTS exposures are not expected for this DPS since the Navy's quantitative analysis predicted all instances of PTS and TTS with green turtles would occur in nearshore waters. The quantitative analysis estimated 2,381 exposures annually of green sea turtles that could result in behavioral responses, but only 17 percent (405) of these were predicted to occur in offshore portions of the Action Area. Based on the Navy's quantitative model, and assuming up to five percent of these offshore exposures could be from this DPS, we expect an annual average of 21 exposures resulting in a short-term behavioral responses for the East Indian-West Pacific DPS. All exposures of East Indian-West Pacific DPS green sea turtles to explosives are expected to be with juvenile or subadult turtles. We anticipate that some individual green sea turtles could be exposed to explosives from the proposed action on multiple occasions within a given year or over their lifetime.

Behavioral response from explosives are expected to be short-term, and are not anticipated to result in reduced fitness of individual turtles. In addition, since there are no nests from this DPS in the action area (Frey et al. 2013; Kittinger et al. 2013), behavioral responses to explosives would have no impact on East Indian-West Pacific DPS green sea turtle reproductive behavior or nesting success. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

In summary, we anticipate a very small number of individual East Indian-West Pacific DPS green sea turtles, relative to the population size, would be affected by the proposed action. Those effects would likely be limited to only minor, short-term behavioral responses with no resulting reductions in numbers, reproduction or individual fitness. We do not anticipate any effects from the proposed action would result in the mortality, injury or reduced fitness of individual East Indian-West Pacific DPS green sea turtles. The impacts expected to occur and affect East Indian-West Pacific DPS green sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of East Indian-West Pacific DPS green sea turtles in the wild.

10.2.2 Hawksbill sea turtle

The hawksbill sea turtle was listed as endangered throughout its entire range on June 2, 1970 under the Endangered Species Conservation Act of 1969, a precursor to the ESA. The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. The historical decline of hawksbill sea turtles is primarily attributed to centuries of exploitation for the species' ornate shell (Parsons 1972). The continuing demand for hawksbills shells, as well as other products derived from this species, represents an ongoing threat to its recovery. Due to their preference to feed on sponges associated with coral reefs, hawksbill sea turtles are particularly sensitive to losses of coral reef communities. Several threats from other manmade and natural sources remain, including poaching, incidental capture in commercial and artisanal fisheries, climate change, and coastal development.

Based on surveys conducted at 88 nesting sites worldwide, approximately 25,500 female hawksbills nest annually (NMFS and USFWS 2013a). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a larger proportion of the nesting sites are declining. However, the Pacific population still has the largest overall abundance of the three ocean basin populations. Major hawksbill nesting rookeries in the Pacific Ocean are located far from the Action Area in Australia, Indonesia, and Papua New Guinea (NMFS and USFWS 2013a). An extremely small number of hawksbill nests have been documented within the action area. The continued directed take of juvenile hawksbills in the action area has the potential to negatively impact local populations (Summers et al. 2018a) given the species' imperiled status in CNMI (Summers et al. 2017).

Based on our *Effects Analysis* (Section 8.2.2), we estimate there would be up to two vessel strikes (one lethal and one non-lethal) of hawksbill turtles annually as a result of the proposed action. The mortality of any individual sea turtle from a population represents the loss of 100 percent of that individual's reproductive potential. Since some of the turtles killed by vessel strike could be females, the proposed action may also result in a reduction in reproduction of this species. Loss of a sexually mature female will have immediate effects on recruitment while lost reproductive potential from mortality of a juvenile female might not be realized for several years. For long-lived species, such as sea turtles, mortality of juveniles or subadults affects future reproductive potential and could have effects on a population for decades.

An average of between 11,000 and 12,700 hawksbill nests are estimated to occur each year in the Pacific. On average hawksbill turtles nest every two or three years, and lay 4.5 nests each year (USFWS 2012). Conservatively assuming that most turtles nest every two years and assuming the lower estimate of the number of nests annually, this equates to a likely total population size in the Pacific basin of approximately 4,889 females. The loss of one female hawksbill in a given year due to vessel strike would reduce the reproductive potential of the Pacific population by about 0.01 percent (note: this is a conservatively high annual rate of reproductive potential reduction since not all those killed would be females and not all juveniles/subadults killed would survive to adulthood). We do not consider this to be an appreciable reduction in the numbers of female green sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. The anticipated proportional loss of current and future reproductive potential is relatively small 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 this population of Central West Pacific DPS green sea turtles, we do not expect this level of mortality to impact the survival or recovery of this population.

Up to one juvenile or subadult hawksbill sea turtle per year is also expected to experience sub-lethal effects from a vessel strike as a result of the proposed action. Injury from a vessel strike may result in temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect the level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population.

From our *Effects Analysis* (Section 8.2.2), we also anticipate hawksbill sea turtles would experience behavioral responses from exposure to explosives used during MITT activities. We expect an annual average of 46 exposures resulting in a behavioral responses. The Navy's quantitative model predicts that no hawksbill sea turtles are likely to be exposed to the levels of explosive sound and energy that could cause injury, PTS, or TTS. Similar to vessel strike exposures, we expect that hawksbill exposures to explosives would likely be with juvenile and subadults turtles. We anticipate that some individual hawksbill sea turtles could be exposed to explosives from the proposed action on multiple occasions within a given year or over their lifetime.

Behavioral response from explosives are expected to be short-term, and are not anticipated to result in reduced fitness of individual turtles. In addition, since so very few hawksbill nests occur within the action area (Frey et al. 2013; Kittinger et al. 2013)(Frey et al. 2013; Kittinger et al. 2013)(Frey et al. 2013; Kittinger et al. 2013)(Frey et al. 2013; Kittinger et al. 2013)(Frey et al. 2013; Kittinger et al. 2013)(Frey et al. 2013; Kittinger et al. 2013), behavioral responses to explosives are not expected to appreciably impact hawksbill sea turtle reproductive behavior or nesting success. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

In summary, we anticipate an extremely small number of individual hawksbills, relative to the population size, would be killed or injured as a result of vessel strike. Other hawksbills may experience minor, short-term behavioral responses due to explosives but we do not anticipate such effects would increase the risk of mortality or injury, nor would they result in the reduced fitness of individual turtles. The impacts expected to occur and affect hawksbill sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of hawksbill sea turtles in the wild.

10.2.3 Leatherback Sea Turtle

The leatherback sea turtle was listed as endangered throughout its entire range on June 2, 1970, under the Endangered Species Conservation Act of 1969, a precursor to the ESA. The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Plastic ingestion is also common in leatherbacks and can block gastrointestinal tracts leading to death.

Pacific leatherbacks are split into western and eastern Pacific subpopulations based on their distribution and biological and genetic characteristics. Only western Pacific leatherbacks are expected to be found within the MITT Action Area. Western Pacific leatherbacks nest in the Indo-Pacific, primarily in Indonesia, Papua New Guinea and the Solomon Islands. Spotila et al. (2000) estimated that the Pacific leatherback population declined from an estimated 81,000 adult turtles to 2,955 females (adult and subadult) in the two decades from 1980 to 2000. The current overall estimate for Papua Barat, Indonesia, Papua New Guinea, and Solomon Islands is 5,000 to 10,000 nests per year (NMFS and USFWS 2013b). Based on nest count data, average clutch frequency, and leatherback remigration interval (i.e., the time in between nesting), NMFS (2017a) derived an estimate of 562 as the annual number of nesting females for the West Pacific subpopulation. The 2013 Leatherback Sea Turtle Review (NMFS and USFWS 2013b) acknowledges varying estimates of 1,775-4,500 total nesting females western Pacific leatherback sea turtles based on nest counts at the major nesting beaches.

Leatherbacks sightings in the action area are rare. Leatherbacks are not known to nest on any islands within the CNMI or Guam. Since leatherback occurrences in the waters off Guam and the CNMI would most likely involve individuals in transit, occurrence is not expected in coastal (i.e., shelf) waters around any of the islands in the action area.

Based on our *Effects Analysis* (Section 8.2.2), we determined that while there would be vessel strikes of ESA-listed sea turtles in the nearshore portions of the Action Area, since leatherback sea turtles are expected to be found only in the offshore portions of the Action Area, the likelihood of a Navy vessel strike of this species is so low as to be considered discountable. Also from our *Effects Analysis*, we anticipate a small number of leatherback sea turtles would experience behavioral harassment from exposure to explosives used during MITT activities. We expect an annual average of one leatherback exposure resulting in a behavioral harassment. The Navy's quantitative model predicts that no leatherbacks are likely to be exposed to the levels of explosive sound and energy that could cause injury, PTS, or TTS. Behavioral responses from explosives are expected to be short-term, and are not anticipated to result in reduced fitness of individual turtles. In addition, since leatherback nests do not occur within the action area (Frey et al. 2013; Kittinger et al. 2013) behavioral responses to explosives would have no impact on reproductive behavior or nesting success. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

In summary, we anticipate an extremely small number of individual leatherbacks, relative to the population size, would be affected by the proposed action. Those effects would likely be limited to only minor, short-term behavioral responses with no resulting reductions in numbers, reproduction or individual fitness. We do not anticipate any effects from the proposed action would result in the mortality, injury or reduced fitness of individual leatherback sea turtles. The impacts expected to occur and affect leatherback sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of leatherback sea turtles in the wild.

10.2.4 Loggerhead Sea Turtle – North Pacific DPS

Loggerhead sea turtles were first listed as threatened under the ESA in 1978. In 2011, NMFS designated nine DPSs of loggerhead sea turtles, including the North Pacific DPS which was listed as endangered. Neritic juveniles and adults in this DPS are at risk of bycatch mortality from coastal fisheries in Japan and Baja California, Mexico. Habitat degradation in the form of coastal development and armoring pose an ongoing threat to nesting females.

The North Pacific DPS has a nesting population of about 2,300 nesting females (Matsuzawa 2011). Almost all loggerheads in the North Pacific seem to stem from Japanese nesting beaches (Bowen et al. 1995; Resendiz et al. 1998). There was a steep (fifty to ninety percent) decline in the annual nesting population in Japan during the last half of the twentieth century (Kamezaki et al. 2003). Since then, nesting has gradually increased, but is still considered to be depressed

compared to historical numbers, and the population growth rate, based on the latest (2009) status review, is negative (-0.032) (Conant et al. 2009). Genetic studies have revealed a complex population sub-structure for the North Pacific DPS with nine haplotypes identified within the North Pacific DPS. Loggerhead turtles are considered rare within the action area. Since loggerhead occurrences in the waters off Guam and the CNMI would most likely involve individuals in transit, occurrence is not expected in coastal (i.e., shelf) waters around any of the islands in the action area.

Based on our *Effects Analysis* (Section 8.2.2), we estimate there would be vessel strikes of sea turtles in the nearshore portions of the Action Area. Since loggerhead sea turtles are expected to be found only in the offshore portions of the Action Area, we determined that the likelihood of a Navy vessel strike of this species is so low as to be considered discountable. From our *Effects Analysis*, we also anticipate a small number of loggerhead sea turtles would experience behavioral responses from exposure to explosives used during MITT activities. We expect an annual average of one loggerhead exposure resulting in a behavioral harassment. The Navy's quantitative model predicts that no loggerheads are likely to be exposed to the levels of explosive sound and energy that could cause injury, PTS, or TTS.

Behavioral responses from explosives are expected to be short-term, and are not anticipated to result in reduced fitness of individual turtles. In addition, since loggerhead nests do not occur within the action area (Frey et al. 2013; Kittinger et al. 2013), behavioral responses to explosives would have no impact on loggerhead reproductive behavior or nesting success. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

In summary, we anticipate an extremely small number of individual loggerheads, relative to the population size, would be affected by the proposed action. Those effects would likely be limited to only minor, short-term behavioral responses with no resulting reductions in numbers, reproduction or individual fitness. We do not anticipate any effects from the proposed action would result in the mortality or reduced fitness of individual loggerhead sea turtles. The impacts expected to occur and affect loggerhead sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of loggerhead sea turtles in the wild.

10.3 Fishes

All of the anticipated adverse impacts to ESA-listed fish in the action area resulting from the Navy's proposed action are from explosives. Other stressors described in this biological opinion were found to not likely adversely affect ESA-listed fish given one or some combination of the following factors: 1) characteristics of these stressors and likely responses by ESA-listed fish, 2) the relatively low frequency and dispersed nature of activities resulting in these stressors

throughout the expansive Action Area, 3) the distribution and life stages of ESA-listed fish in the action area, and 4) the low likelihood of species co-occurrence with these stressors.

While this biological opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the abundance and behavior of fish when exposed to explosives. Fish that are killed and removed from the population would decrease reproductive rates, and those that sustain non-lethal injuries could have fitness consequences during the time it takes to fully recover, or have longer lasting impacts if permanently harmed. Temporary hearing impairment and significant behavioral disruption could have similar effects, but these impacts are expected to be temporary and a fish's hearing is expected to return back to normal after some healing duration. While this may have an energetic cost to the individual for the time it takes to heal, we do not anticipate fitness consequences to an individual fish from temporary hearing loss over the long-term. Fish could have a diminished ability to detect threats in their environment, or have a temporary reduction in foraging success or other life functions while they recover. This would be intensified if sustained periods of harassment or multiple exposures occurred. These periods of behavioral responses may result in fish avoiding or leaving the immediate area during Navy activities involving explosives. This could cause individuals to expend more energy seeking suitable habitat elsewhere, having the potential to result in reduced growth rates, older age to maturity, and lower lifetime fecundity. However, because Navy activities involving explosives are short-term, episodic and temporary, we would not expect the most severe effects from behavioral responses to rise to such magnitude that would reduce an individual's fitness.

In this section we assess the likely consequences of effects from explosives on ESA-listed fish that have been exposed, the populations those individuals represent, and the species those populations comprise. The *Species Likely to be Adversely Affected* sections above (Sections 6.2.10, 6.2.11, and 6.2.12) describe current ESA-listed fish population statuses and the threats to their survival and recovery.

10.3.1 Scalloped Hammerhead Shark – Indo-West Pacific DPS

The Indo-West Pacific DPS scalloped hammerhead was listed as threatened in 2014. The scalloped hammerhead shark is primarily a shallow water, coastal species. Oceanic islands and seamounts represent important habitat for this species (Nalesso et al. 2019). The density of scalloped hammerhead sharks in the shallow, nearshore waters of the Action Area are not well understood but anecdotal evidence suggests Inner Apra Harbor may serve as nursery habitat for this species (Miller et al. 2014a).

Based on a combination of fisheries dependent and fisheries independent data, it is estimated that hammerhead shark populations have experienced drastic population declines, in excess of 90 percent, in several parts of their global range (Gallagher et al. 2014). The primary factors responsible for the decline of hammerheads are overutilization, due to both catch and bycatch in fisheries, illegal fishing, and inadequate regulatory mechanisms for protecting sharks (Miller et

al. 2014a). Evidence of heavy fishing pressure by industrial, commercial and artisanal fisheries, reports of significant illegal, unreported, unregulated fishing, especially off the coast of Australia, and high at-vessel mortality rates have contributed to overutilization of the Indo-West Pacific DPS. Scalloped hammerhead sharks are afforded some protections from overharvesting within the action area (Miller and Klimovich 2017). The Micronesia Regional Shark Sanctuary Declaration, which includes the EEZs of Guam and CNMI, prohibits possession, sale, distribution and trade of sharks and rays (and shark and ray parts), with some limited exemptions for research and subsistence fishing. Illegal harvest is likely still a problem given the large area and limited enforcement available.

Based on our *Effects Analysis* (Section 8.2.3 above), scalloped hammerheads are only expected to be adversely affected by MITT activities involving the use of explosives. Given their size, elongated body shape, and lack of a swim bladder, scalloped hammerheads are likely less susceptible to injury or mortality from exposure to explosives compared to some other fish species. Scalloped hammerheads could also experience masking, physiological stress, and behavioral reactions from explosives in this area. Most physiological stress and behavioral effects are expected to be temporary, of a short duration, with the individual shark returning to a normal state quickly after cessation of the blast wave.

In our *Effects Analysis*, we were unable to quantitatively estimate the number of scalloped hammerheads likely to be exposed to explosives in a manner that would result in adverse effects due to the lack of abundance information for this species within the action area. Due to the dispersed, infrequent occurrence and short duration of explosive use, and the low density of scalloped hammerhead sharks anticipated to occur in offshore portions of the Action Area, it is unlikely that this species would be exposed to higher impact explosives (i.e., NEWs >20 lbs) in offshore areas. Explosives that hammerheads are more likely to be exposed to (i.e., < 20 lb NEW in nearshore areas) produce smaller ranges to higher order effects such as mortality or injury compared to explosives in larger bin sizes, thus reducing the potential that scalloped hammerhead sharks would incur impacts that could lead to fitness consequences. The Navy's proposed continuation of procedural mitigation to avoid or reduce potential impacts on scalloped hammerhead sharks from explosive mine neutralization activities involving Navy divers should further reduce the number of exposures, as well as the impacts of those exposures, in nearshore areas. Only a small number of those individuals exposed to explosives are expected to be exposed at levels that would impact fitness, with even fewer expected to be exposed to levels that would result in injury or mortality. If Inner Apra Harbor and Sasa Bay act as a nursery for scalloped hammerhead sharks, adult females could be exposed to the effects from explosions within the Navy's Outer Apra Harbor UNDET during anticipated frequent movements between these nursery grounds and nearshore areas outside the harbor. We would not anticipate explosives exposures of adults, neonates or juveniles within Inner Apra Harbor or Sasa Bay given the distance from these areas to the UNDET site.

While we could not quantify the precise number of scalloped hammerhead sharks that may be adversely affected, we anticipate only an extremely small number of individual hammerhead sharks, relative to the population size, would be affected by the proposed action. Although, based on the best scientific information, an abundance estimate for the entire Indo-West Pacific DPS is unavailable, the DPS range covers a very large area (see Figure 39). The limited nearshore areas where scalloped hammerheads could potentially be exposed to the effects of Navy explosives are extremely small by comparison. While we cannot quantify the proportion of the population that would be impacted, based on the best available information, we expect this proportion to be extremely small. The majority of the anticipated effects would likely be only minor, short-term behavioral responses with no resulting reductions in numbers, reproduction or individual fitness. We anticipate a very small number of Indo-West Pacific DPS scalloped hammerheads, including the possibility of mature females, would be exposed to explosives at levels that would impact fitness (i.e., through behavioral harassment resulting in a significant effect on important life functions), with even fewer expected to be exposed to levels that would result in injury or mortality. The loss of a mature female would represent an immediate reduction in the reproductive potential of the population. Depending on the severity and timing, sublethal effects (e.g., injury, behavioral harassment with fitness consequences) could also result in reduced reproductive potential of the population. However, as noted above, we expect the number of adult female mortalities, injuries or behavioral harassment with fitness consequences resulting from the proposed action to be extremely small compared to the number of adult females in the entire Indo-West Pacific DPS. In summary, the impacts expected to occur and affect scalloped hammerheads in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, numbers or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of Indo-West Pacific DPS scalloped hammerhead sharks in the wild.

10.3.2 Giant Manta Ray

The giant manta ray was listed as threatened under the ESA in 2018. This species occupies tropical, subtropical, and temperate oceanic waters and productive coastlines throughout the world. Giant manta rays are commonly found offshore in oceanic waters, but are sometimes found in shallow waters (less than 10 m) during the day (Lawson et al. 2017; Miller and Klimovich 2017). While data on global trends of the species are unavailable, in the Indo-Pacific there have been decreases in landings of up to 95 percent. The best available data do not indicate genetic discreteness between giant manta rays in the Atlantic and those in the Indo-Pacific and eastern Pacific (Miller and Klimovich 2017). There are no current or historical estimates of giant manta ray range-wide abundance, although there are some rough estimates of subpopulation size based on anecdotal accounts from fishermen and divers. There are about 11 subpopulation estimates worldwide (perhaps more), and these subpopulation estimates range from 100 to 1,500 individuals each (FAO 2012; Miller and Klimovich 2017).

As discussed in giant manta ray species status section (Section 6.2.11 above) and the *Environmental Baseline* (Section 7), interactions with commercial fisheries are the main threat to this species. Along with other mobulids, giant manta rays are targeted for their gill rakers, which are dried and sold in Asia (O'Malley et al. 2017). Based on the doubling of the amount of mobulid gill rakers in Asian markets from 2011 to 2015, we expect targeted commercial fishing to remain a threat to the species into the foreseeable future. In addition to being targeted for their gill rakers, giant manta rays are also bycaught in industrial purse seine and artisanal gillnet fisheries, particularly in the eastern Pacific and the Indo-Pacific. Giant manta rays are afforded some protections from overharvesting within the action area (Miller and Klimovich 2017). The Micronesia Regional Shark Sanctuary Declaration, which includes the EEZs of Guam and CNMI, prohibits possession, sale, distribution and trade of sharks and rays (including shark and ray parts), with some limited exemptions for research and subsistence fishing. Illegal harvest is likely still a problem given the large area and limited enforcement available.

Based on our effects analysis (Section 8.2.3 above), giant manta rays are only expected to be adversely affected by MITT activities involving the use of explosives. However, given their size and lack of a swim bladder, giant manta rays are likely less susceptible to injury or mortality from exposure to explosives compared to some other fish species. Giant manta rays could also experience masking, physiological stress, and behavioral reactions from explosives in this area. Most physiological stress and behavioral effects are expected to be temporary, of a short duration, with the individual ray returning to a normal state quickly after cessation of the blast wave.

In our *Effects Analysis*, we were unable to quantitatively estimate the number of giant manta rays likely to be exposed to explosives in a manner that would result in adverse effects due to the lack of abundance information within the action area. Due to the dispersed, infrequent occurrence and short duration of explosive use in areas where giant manta rays are likely to be found, and the anticipated low density of this species in the action area, exposures to explosives are expected to be rare. Although a range-wide abundance estimate for giant manta rays is unavailable, the species has a global distribution consisting of at least 11 subpopulations (FAO 2012; Miller and Klimovich 2017). The potential overlap between giant manta rays and the effects from Navy explosives (i.e., in time and space) is extremely small compared to the overall area covered by the species (see Figure 40 above). While we cannot quantify the proportion of the population that would be impacted, based on the best available information, we expect this proportion to be extremely small. The Navy's proposed procedural mitigation to avoid or reduce potential impacts on giant manta rays from explosive mine neutralization activities involving Navy divers (see Section 3.6.2 for details) should further reduce the number of exposures, as well as the impacts of those exposures, in nearshore areas. Only a small number of those individuals exposed to explosives are expected to be exposed at levels that would impact fitness (i.e., through behavioral harassment resulting in a significant effect on important life functions), with even fewer expected to be exposed to levels that would result in injury or mortality. The loss of

a mature female giant manta ray would represent an immediate reduction in the reproductive potential of the population. Depending on the severity and timing, sublethal effects (e.g., injury, behavioral harassment with fitness consequences) could also result in reduced reproductive potential of the population. However, as noted above, we expect the number of adult female mortalities, injuries or behavioral harassment with fitness consequences resulting from the proposed action to be extremely small compared to the number of adult female giant manta rays occurring throughout the species' global range.

In summary, although we could not quantify the effects, we anticipate a small number of individual giant manta rays, relative to the population size, would be affected by the proposed action. The majority of those effects would likely be only minor, short-term behavioral responses with no resulting reductions in numbers, reproduction or individual fitness. We anticipate a very small number of giant manta rays would be exposed to explosives at levels that would impact fitness, with even fewer expected to be exposed to levels that would result in injury or mortality. The impacts expected to occur and affect giant manta rays in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, numbers or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of giant manta rays in the wild.

10.3.3 Oceanic Whitetip Shark

The oceanic whitetip shark was listed as threatened under the ESA in 2018. This pelagic species is distributed worldwide in tropical and subtropical waters. While there is no range-wide abundance estimate available, it was once one of the most abundant sharks in the ocean. Catch data from individual ocean basins indicate that the populations have undergone significant declines (Young et al. 2017). Populations in the Eastern Pacific Ocean are thought to have declined between 80 and 90 percent since the late 1990s (Hall 2013). While little information on genetic diversity exists for the species, some data indicate they have low genetic diversity making the species susceptible to inbreeding and 'Allee' effects, although the extent to which is currently unknown. There is mixed evidence regarding genetic structuring and population differentiation across ocean basins, but to date there is no unequivocal evidence for genetic discontinuity or marked separation between Atlantic and Indo-Pacific subpopulations (Young et al. 2017).

In the oceanic whitetip shark species status section (Section 6.2.12 above) and the *Environmental Baseline* (Section 7), we identified fisheries interactions, from both targeted and non-targeted (i.e., bycatch) fisheries, as the main threat to this species. Due to the species' vertical and horizontal distribution, oceanic whitetip sharks are frequently caught as bycatch in many commercial fisheries, including pelagic longline fisheries targeting tuna and swordfish, purse seine, gillnet, and artisanal fisheries. In addition, they are directly targeted by some fisheries for their large, morphologically distinct fins, which sell for a high price in the Asian fin market. Oceanic whitetip sharks are afforded some protections from overharvesting within the action area (Miller and Klimovich 2017). The Micronesia Regional Shark Sanctuary Declaration, which

includes the EEZs of Guam and CNMI, prohibits possession, sale, distribution and trade of sharks and rays (including shark and ray parts), with some limited exemptions for research and subsistence fishing. Illegal harvest is likely still a problem given the large area and limited enforcement available. Given the inadequacy of existing regulatory measures and enforcement at a global scale, fisheries interactions are expected to remain a threat to this species into the foreseeable future.

Based on our effects analysis (Section 8.2.3 above), oceanic whitetip sharks are only expected to be adversely affected by MITT activities involving the use of explosives. Oceanic whitetip sharks spend much of their time at the surface, potentially increasing the risk of exposure to surface detonations. Given their size, elongated body shape and lack of a swim bladder, oceanic whitetip sharks are likely less susceptible to injury or mortality from exposure to explosives compared to some other fish species. Oceanic whitetip sharks could also experience masking, physiological stress, and behavioral reactions from explosives in this area. Most physiological stress and behavioral effects are expected to be temporary, of a short duration, with the individual shark returning to a normal state quickly after cessation of the blast wave.

In our *Effects Analysis*, we were unable to quantitatively estimate the number of oceanic whitetip sharks likely to be exposed to explosives in a manner that would result in adverse effects due to the lack of abundance information within the action area. Due to the dispersed, infrequent occurrence and short duration of explosive use in offshore areas where oceanic whitetips are likely to be found, and the anticipated low density of this species in the action area, exposures to explosives are expected to be rare. Although a range-wide abundance estimate for oceanic whitetip sharks is unavailable, this species is distributed worldwide in tropical and subtropical waters between 10° North and 10° South (see Figure 41 above). The potential overlap between oceanic whitetip sharks and the effects from Navy explosives (i.e., in time and space) is extremely small compared to the overall area covered by the species. While we cannot quantify the proportion of the population that would be impacted, based on the best available information, we expect this proportion to be extremely small. Only a small number of those individuals exposed to explosives are expected to be exposed at levels that would impact fitness (i.e., through behavioral harassment resulting in a significant effect on important life functions), with even fewer expected to be exposed to levels that would result in injury or mortality. The loss of a mature female oceanic whitetip shark would represent an immediate reduction in the reproductive potential of the population. Depending on the severity and timing, sublethal effects (e.g., injury, behavioral harassment with fitness consequences) could also result in reduced reproductive potential of the population. However, as noted above, we expect the number of adult female mortalities, injuries or behavioral harassment with fitness consequences resulting from the proposed action to be extremely small compared to the number of adult female oceanic whitetip sharks occurring throughout the species' global range.

In summary, although we could not quantify the effects, we anticipate a small number of individual oceanic whitetip sharks, relative to the population size, would be affected by the

proposed action. The majority of those effects would likely be only minor, short-term behavioral responses with no resulting reductions in numbers, reproduction or individual fitness. We anticipate a very small number of oceanic whitetips would be exposed to explosives at levels that would impact fitness, with even fewer expected to be exposed to levels that would result in injury or mortality. The impacts expected to occur and affect oceanic whitetips in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, numbers or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of oceanic whitetip sharks in the wild.

10.4 Coral - *Acropora globiceps*

Acropora globiceps was listed under the ESA as threatened on September 10, 2014 (79 FR 53852). In determining whether U.S. Navy training and testing activities in the MITT Action Area are likely to jeopardize the survival and recovery of *Acropora globiceps*, we assessed effects of the action against the aggregate effects of everything in the *Environmental Baseline* that has led to the current *Status of Listed Resources* and, those effects of future non-Federal activities that are reasonably certain to occur within the action area in the reasonably foreseeable future.

Our effects analysis determined that colonies of *Acropora globiceps* around FDM would likely be impacted from in-water explosions and direct strike from live and inert ordnance. The large majority of impacts are estimated to result from high explosive bombs that miss their intended on-shore target. Though we are unable to provide a quantitative estimate of the number of *Acropora globiceps* colonies impacted by Navy activities at FDM (see Section 8.2.4 for additional details), we conservatively estimate that this species may be exposed to the adverse effects from Navy activities involving the use of explosives and other expended materials on FDM within the subset of the total estimated area (i.e., 9,020 square meters) impacted annually which contains habitat suitable for *Acropora globiceps* colonies to survive (i.e., with existing live coral cover and in water less than 30 m deep).

During a 2017 FDM coral reef survey, only a single confirmed colony of *Acropora globiceps* was sighted in waters less than 20 m deep, indicating it is rare around FDM (Carilli et al. 2018). The sighting location of this colony is not immediately adjacent to impact zones for explosive munitions; rather it is immediately adjacent to a no fire zone, and in close proximity to an inert ordnance only zone. While a small portion of the nearshore marine habitat surrounding FDM impacted by MITT activities involving explosives is likely to contain colonies of *Acropora globiceps* that could be injured or killed, the majority of the area impacted will not contain this species. Although individual colonies and clusters of colonies forming a small-scale reefscape are likely to be negatively impacted by impulsive explosions, underwater surveys of FDM reefs suggest significant population level impacts are not likely to occur, and colony repair or successful recruitment will likely occur within two to three years following disturbance (Smith and Marx Jr. 2016). Smith and Marx Jr. (2016) documented that while impacts to reef habitat have occurred around FDM (i.e., from ordnance that skipped off the island, from ordnance

fragments, and from an in-water detonation), no significant impacts to the physical or biological environment were detected between 2005 and 2012. Instead, the authors suggested that restricted access to FDM because it is a bombing range has resulted in a de-facto preserve effect. Additionally, the area of nearshore habitat that is expected to be affected by explosives and military expended material at FDM is infinitesimally small in relation to available habitat within this species' range. *Acropora globiceps*, and other ESA-listed corals in the Indo-Pacific, consist of at least millions of colonies, and occur across a range of thousands of miles.

While detonations from the proposed action may result in the mortality of the developmental stages of *Acropora globiceps* around FDM and elsewhere in the action area, it likely would have an insignificant effect on the reproductive potential for an individual colony of the species or recruitment at the population level of this species. Since this level of effect is not expected to be significant and detectable at the individual level (i.e., colony) we would not consider this effect to be a reduction in fitness of any colony of *Acropora globiceps* and thus we do not anticipate any population-level effects. Because the species is sparsely populated across a wide range, localized impacts to potential coral reef habitat for this species are not expected to impact the species' ability to reproduce. Instead, other stressors, not associated with the proposed action, that affect corals over a broad geographic scale are larger drivers of the ability of *Acropora globiceps* to survive and recover. These include ocean warming, disease, ocean acidification, trophic effects of fishing, nutrients, and predation.

In summary, the impacts expected to occur and affect *Acropora globiceps* in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, numbers or distribution of this species. For this reason, the effects of the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of *Acropora globiceps* in the wild.

11 CONCLUSION

We find that the proposed action is **not likely to adversely affect** olive ridley sea turtles (all other areas/not Mexico's Pacific Coast breeding colonies), *Acropora retusa*, and *Seriatopora aculeata*; thus, it is also not likely to jeopardize the continued existence of these species.

After reviewing the current status of the species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is **not likely to jeopardize** the continued existence of the following ESA-listed species: blue whale, fin whale, Western North Pacific DPS humpback whale, sei whale, sperm whale, Central West Pacific DPS green sea turtle, Central North Pacific DPS green sea turtle, East Indian-West Pacific DPS green sea turtle, hawksbill sea turtle, leatherback sea turtle, North Pacific DPS loggerhead sea turtle, Indo-West Pacific DPS scalloped hammerhead shark, oceanic whitetip shark, giant manta ray, and *Acropora globiceps*.

12 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. In the case of threatened species, section 4(d) of the ESA leaves it to the Secretary's discretion whether and to what extent to extend the statutory 9(a) ''take'' prohibitions, and directs the agency to issue regulations it considers necessary and advisable for the conservation of the species. At the time of this consultation, take prohibitions have not been extended to the following threatened species: oceanic whitetip shark; giant manta ray; Indo-Pacific DPS scalloped hammerhead shark; and *Acropora globiceps*. However, consistent with *CBD v. Salazar*, 695 F.3d 893 (9th Cir. 2012), we assessed the amount or extent of take to these threatened species that is anticipated incidental to Navy training and testing activities and include this information in the ITS. Inclusion of these species in the ITS serves to assist the action agency with monitoring of take and provides a trigger for reinitiation if levels of estimated take are exceeded.

"Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. NMFS had not yet defined "harass" under the ESA in regulation, but has issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." We applied NMFS' interim definition of harassment in evaluating whether the proposed activities are likely to result in harassment of ESA-listed species. Incidental take statements serve a number of functions, including providing reinitiation triggers for all anticipated take, providing exemptions from section 9 liability for prohibited take, and identifying reasonable and prudent measures and implementing terms and conditions that will minimize the impact of anticipated incidental take.

Further, when an action will result in incidental take of ESA-listed cetaceans, ESA section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an ITS for ESA-listed cetaceans and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS, including those specified as necessary to comply with the MMPA, Section 101(a)(5). Accordingly, the terms of this ITS and the exemption from section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the cetaceans identified here. Absent such authorization, this ITS is inoperative for ESA-listed cetaceans.

12.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by the proposed action. The extent of take represents the "extent of land or marine area that may be affected by an action" and may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953). Table 85 shows the anticipated take from training and testing activities by species and the interrelated and interdependent actions of issuance of a seven-year regulation and LOAs by NMFS' Permits Division to authorize take of cetaceans pursuant to the MMPA. The amount of take resulting from MITT Phase III activities was estimated based on the best information available.

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take (C.F.R. §402.14(i)(1)(i)). A surrogate may be used when the following three conditions are met. The ITS: (i) describes the causal link between the surrogate and take of the listed species, (ii) explains 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 (iii) sets a clear standard for determining when the level of anticipated take has been exceeded. As described previously in Section 8.2.3 above, due to the lack of available density and abundance information for ESA-listed fish in the action area, 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 mortality, injury, TTS, and behavioral disruption) of ESA-listed fish species (Indo-West Pacific DPS scalloped hammerhead shark, oceanic whitetip shark, giant manta ray) or to monitor take-related impacts in terms of individuals of these species. Therefore, we have developed a surrogate that satisfies the three criteria described above. The surrogate for the incidental take of ESA-listed fish is the distance to reach effects (i.e., range to effects) in the water column that correlates with injury and sub-injury from explosives in those areas occupied by fish (See Section 8.2.3 for details). We find it reasonable to assume that there is a positive (causal) relationship between the range to effects from explosives and the number of individuals of ESA-listed fish species that will be taken. That is, as the range to effects increases, the number of fish within that range and, therefore, at risk of exposure to adverse effects from explosives also increases. As a surrogate, this measure would be exceeded if the proposed action resulted in range to effects beyond those anticipated from our effects analysis (e.g., use of explosives with greater NEW than included in the proposed action).

Table 85. The number of lethal and non-lethal takes of threatened and endangered cetaceans and sea turtles likely to occur annually* as a result of the proposed Navy training and testing activities in the action area.

ESA-Listed Species	Impulsive and Non-Impulsive Acoustic Stressors					Vessel Strike	
	Harassment Behavioral	Harassment TTS	Harm (PTS)	Harm (Slight Lung Injury)	Mortality	Mortality	Harm(non-lethal injuries)
Marine Mammals							
Blue Whale	4	20	0	0	0	0	0
Fin Whale	5	20	0	0	0	0	0
Humpback Whale – Western North Pacific DPS Non-Calf Adults	72	529	0	0	0	0	0
Humpback Whale Mother-Calf Pairs**	20 (10 mother; 10 calf)	150 (75 mother; 75 calf)	2* (1 mother; 1 calf)	0	0	0	0
Sei Whale	19	136	0	0	0	0	0
Sperm Whale	192	11	0	0	0	0	0
Sea Turtles							
Green – Central West Pacific DPS	2,381***	6***	3***	0	0	10	4
Green –East Indian-West Pacific DPS						0	0
Green – Central North Pacific DPS						1	1
Hawksbill	46	0	0	0	0	1	1
Leatherback	1	0	0	0	0	0	0
Loggerhead – North Pacific DPS	1	0	0	0	0	0	0

* We estimate one PTS exposure of a mother-calf pair (i.e., 2 takes) approximately every nine years.

** Mother-calf pair takes are assumed to occur simultaneously.

***Available information does not allow us to quantitatively assign acoustic take estimates to specific green sea turtle DPSs, though the vast majority of individuals affected are expected to be from the Central West Pacific DPS. See Section 8.2.2 for further detail and analysis.

As noted above, a surrogate may be used when the following three conditions are met. The ITS: (i) describes the causal link between the surrogate and take of the listed species, (ii) explains 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 (iii) sets a clear standard for determining when the level of anticipated take has been exceeded. These three criteria are met for *Acropora globiceps*. Due to the lack of data on the abundance and distribution of ESA-listed corals in the action area (Section 6.2.13), it is not practical or possible to express the amount or extent of anticipated take of *Acropora globiceps*, or to monitor take-related impacts in terms of individuals of this species. Therefore, the incidental take of *Acropora globiceps* (in the form of injury) is expressed as a surrogate that meets the three criteria prescribed by 50 CFR 402.14(i). We have established a habitat area surrogate for incidental take of the species. Though we are unable to provide a quantitative estimate of the number of *Acropora globiceps* colonies impacted by Navy activities at FDM, we can qualitatively assess the likelihood that impacts will occur to areas of nearshore habitat that may be suitable for *Acropora globiceps*. From above (Section 8.2.4), we estimated that the total area of nearshore habitat around FDM impacted annually from direct strike and explosive effects is 9,020 square meters. However, only a portion of this total impacted area would likely be suitable as habitat for *Acropora globiceps.* If *Acropora globiceps* colonies occur around FDM (i.e., besides those recently surveyed), we would expect to find them in habitats with live coral cover and at depths between 15 and 25 m (i.e., the depth range where the species was observed during recent coral reef surveys). Thus, we describe the surrogate for take of *Acropora globiceps* as the areas within the total estimated area (i.e., 9,020 square meters) around FDM impacted annually by direct strike and explosive effects, which contain live coral cover and are between the 15 and 25 meter isobaths. We find it reasonable to assume that there is a positive (causal) relationship between the estimated area impacted by explosives and the number of individuals of ESA-listed coral colonies that will be taken. That is, we anticipate that the larger the impacted area, the more individual *Acropora globiceps* colonies would be exposed. As a surrogate, this measure would be exceeded if the proposed action resulted in an estimated impacted area greater than that predicted from our effects analysis (e.g., if new information indicates that the ranges to effects are greater than those analyzed in this opinion).

Activity Levels as Indicators of Take of ESA-listed Species

As discussed in this opinion, the estimated take of ESA-listed sea turtles and cetaceans from acoustic stressors is based on Navy modeling (except for take of humpback whales within the GMAs), which represents the best available means of numerically quantifying take. For both the Navy modeling approach and our approach for estimating humpback whales within the GMAs, as the level of modeled sonar or explosive use increases, the level of take is likely to increase as

well. For non-lethal take from acoustic sources specified above, feasible monitoring techniques for detecting and calculating actual take at the scale of MITT 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 modeling and take estimation approaches used for our analysis, and the link between sonar or explosive use and the level of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this ITS that requires the Navy to report to NMFS any exceedance of activity specified in the preceding opinion and in the final MMPA rule before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level will require the Navy to reinitiate consultation.

The estimated take of ESA-listed sea turtles from ship strike is based on available strandings information and the relative proportion of all vessel activity within the action area attributed to Navy vessel activity. Feasible monitoring techniques for detecting and calculating actual sea turtle take (either lethal or nonlethal) from either civilian or Navy vessel strike do not exist. It should be noted that the ratio of Navy vessels in the action area is significantly less than civilian vessels and boats. Furthermore, even if minor changes to Navy vessel quantities occur, the corresponding overall vessel activity levels remain relatively the same for the foreseeable future based on scheduling needs, deployment cycles, and other logistic considerations (e.g., fuel allocation, personnel availability, etc.). As described in the preceding paragraph, the Navy already reports annual sonar and explosive use to NMFS as a surrogate for authorized annual take as well as an indicator of overall Navy activity levels including vessel movements. Therefore, we can equate annual reporting of Navy activities (sonar, explosives) as a reasonable metric to evaluate if sea turtle ship strike has likely been exceeded. If annual Navy use of sonar and explosives fall below those levels considered in this opinion, then we can reasonably assume Navy vessel activity was also within the same level as analyzed and that sea turtle ship strike risk has not changed.

For ESA-listed fish species, as discussed above, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take of ESA-listed fish species or to monitor take-related impacts in terms of individuals of these species due to the lack of data on fish abundance in the action area. As the level of Navy explosive use increases, the level of take of ESA-listed fish is likely to increase as well. Feasible monitoring techniques for detecting and calculating actual take of ESA-listed fish at the scale of MITT activities do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on Navy activity levels, and the link between explosive use and the level of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this ITS that requires the Navy to report to NMFS any exceedance of explosive activity use specified in the preceding opinion before the exceedance occurs if operational security considerations allow, or as soon as

operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level will require the Navy to reinitiate consultation.

Similarly, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take of *Acropora globiceps* or to monitor take-related impacts in terms of individual colonies due to the lack of data on the abundance and distribution of this species in the action area. As the level of Navy explosive use around FDM increases, the level of take of *Acropora globiceps* is likely to increase as well. Feasible monitoring techniques for detecting and calculating actual take of ESA-listed corals at the scale of MITT activities do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on Navy activity levels, and the link between explosive use and the level of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this ITS that requires the Navy to report to NMFS any exceedance of explosive activity use specified in the preceding opinion before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level will require the Navy to reinitiate consultation.

12.2 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the action, is not likely to result in jeopardy to any ESA-listed species.

12.3 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures and terms and conditions are specified as required by 50 C.F.R. 402.14 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and minimize the impact of that take on ESA-listed species. The reasonable and prudent measures are nondiscretionary, and must be undertaken by the Navy and NMFS' Permits Division so that they become binding conditions for the exemption in section 7(o)(2) to apply.

NMFS has determined the following reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take of threatened and endangered species during the proposed action:

1. The Navy and NMFS Permits Division shall minimize effects to ESA-listed cetaceans, sea turtles, and fish from the use of active sonar, explosives, and vessels during training and testing activities. This includes adherence to the mitigation measures specified in the final MMPA rule and LOA and those measures described in Section 3.6.2 of the preceding opinion.
2. The Navy and NMFS Permits Division shall monitor and report to NMFS' Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed species from the use of sonar and other transducers, explosives, and vessels during training and testing activities. This includes adherence to the monitoring and reporting measures specified in the final MMPA rule and LOA.

12.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Navy and NMFS Permits Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the Navy or NMFS Permits Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

1) The following terms and conditions implement reasonable and prudent measure 1:
   a) The Navy shall implement all mitigation measures as specified in the final MMPA rule and LOA, and as described in this opinion in Section 3.6.2.
   b) NMFS Permits Division shall ensure that all mitigation measures as prescribed in the final rule and LOA, and as described in Section 3.6.2 of this opinion are implemented by the Navy.
   c) The Navy shall continue technical assistance/adaptive management efforts with NMFS to help inform future MITT consultations or reinitiation of this consultation. Adaptive management discussions will include review of Navy's exercise and monitoring reports, review of ESA section 7 reinitiation triggers (described in Section 14 below), and potential new measures to increase mitigation effectiveness (e.g., thermal detection of protected species).
2) The following terms and conditions implement reasonable and prudent measure 2:
   a) The Navy shall monitor training and testing activities and submit reports annually to NMFS Permits Division and NMFS ESA Interagency Cooperation Division including the location and total hours and counts of active sonar hours and in-water explosives used, and an assessment if activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs.

b) The Navy shall monitor and report annual numbers of ordnance by type (e.g., explosive bomb, non-explosive bomb, projectiles, missiles, rockets, etc.) expended at FDM. The Navy shall report all observed ricochets and misses that land in waters surrounding FDM occupied by corals. Additionally, the Navy shall provide reports of any observed in-water effects (e.g., crater size, observed mortality) to corals resulting from detonations of high-explosive ordnance as they are discovered incidental to routine operations or during coral reef surveys to confirm or to help revise assumptions on the effects of high-explosive bombs and other ordnance to corals at various depths.

c) The Navy shall, no less than once every five years, survey coral reef habitat around FDM within 30 m of water depth. These surveys shall be structured to confirm presence or absence and abundance of ESA-listed corals and to assess general trends in coral reef species composition, percent coral coverage, and condition (disease, predators, extent of breakage, etc.).

d) The Navy shall provide a report summarizing the status of and/or providing a final assessment on the Navy's Lookout Effectiveness Study following the end of Calendar Year (CY) 2021. The report will be submitted no later than 90 days after the end of CY2021. The report will provide a statistical assessment of the data available to date characterizing the effectiveness of Navy lookouts relative to trained marine mammal observers (MMOs) for the purposes of implementing the mitigation measures required in this biological opinion.

e) NMFS Permits Division shall review the reports submitted by the Navy described above in 2(a). Within two months of receipt of each Navy report, NMFS Permits Division will submit written documentation to NMFS ESA Interagency Cooperation Division assessing if Navy activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs.

f) The Navy shall report to the NMFS ESA Interagency Cooperation Division all observed injury or mortality of any ESA-listed species resulting from the proposed training and testing activities within the action area. The Navy shall report when enough data are available to determine if the dead or seriously injured ESA-listed species may be attributable to these activities, including but not limited to, the use of explosives and vessel strike.

g) In the event that Navy personnel (uniformed military, civilian, or contractors while conducting Navy work) discover a live or dead stranded marine mammal or sea turtle within the action area or on Navy property, the Navy shall comply with the stranding Notification and Reporting Plan.

h) If NMFS personnel determine that the circumstances of any of the strandings reported in 2(f) suggest investigation of the associated Navy activities is warranted (see stranding

and notification document for example circumstances), and an investigation into the stranding is being pursued, NMFS personnel will submit a written request to the Navy asking that they provide the status of all sound 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. Navy will submit this information as soon as possible, but no later than seven business days after the request.

13 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 CFR 402.02).

1. The Navy should assess the future practicability of implementing vessel speed reductions when operating in the Marpi Reef and Chalan Kanoa Reef Mitigation Areas (Section 3.6.2). NMFS recommends a ten knot limit for vessels transiting through these areas from December through May.

2. To the extent practicable, the Navy should implement a seasonal restriction (December through May) on vessels transiting through Marpi Reef and Chalan Kanoa Reef Mitigation Areas (Section 3.6.2) at night or in low visibility conditions.

3. The Navy should monitor and report sighting, location, and stranding data for ESA-listed cetaceans, sea turtles, and fish in the MITT Action Area.

4. As practicable, the Navy should develop procedures to aid any individual ESA-listed cetacean or sea turtle that has been impacted by MITT activities and is in a condition requiring assistance to increase likelihood of survival.

5. To the extent practicable, the Navy should ensure that at least two Navy Lookouts are available during all sonar exercises that take place within Marpi Reef and Chalan Kanoa Reef Mitigation Areas (Section 3.6.2) to minimize adverse impacts to humpback whales, including mother-calf pairs on their breeding/calving grounds.

6. The Navy should coordinate with NMFS on the collection of information for better understanding the effectiveness of mitigation measures proposed by the Navy during MITT sonar and explosives use. This should include an assessment of the effectiveness of Navy Lookouts for minimizing impacts to ESA-listed species (see (Oliveira et al. 2019)). Findings should be incorporated into the Navy's approach to quantitatively evaluating the effects of acoustics stressors on ESA-listed species.

7. The Navy should continue to model potential impacts to ESA-listed marine mammals and sea turtles using NAEMO and other relevant models. The Navy should validate assumptions used in risk analyses and seek new information and higher quality data for use in such efforts.

8. The Navy should coordinate with NMFS' regional science centers or other entities to collect additional information on scalloped hammerhead shark, oceanic whitetip shark, and giant manta ray abundance and density estimates within the MITT Action Area in order to incorporate into density models in the future. For scalloped hammerhead sharks, this should include additional information on potential nursery and pupping grounds in

and around Sasa Bay, Inner Apra Harbor, and other enclosed bays or suitable nearshore habitat within the action area.

9. The Navy should coordinate with NMFS to monitor for presence of ESA-listed corals in UNDET areas within Apra Harbor, Guam to ensure the absence of these species and to avoid interactions.

10. The Navy should explore methods to better quantify the risk of vessel strike to sea turtles.

11. The Navy should continue the development of autonomous marine mammal detection technologies to reduce the risk of vessel strike.

12. The Navy should continue to conduct behavioral response studies aimed at obtaining response data that is more consistent with the received sound levels, distances, and durations of exposure that animals are likely to receive incidental to actual training and testing activities.

13. As practicable, the Navy should supplement the proposed visual monitoring mitigation measures described in Section 3.6.2 with passive and active acoustic monitoring for activities that could cause cetacean injury or mortality.

14. The Navy should continue to conduct research on thermal detection monitoring systems, as a supplement to visual monitoring, to further minimize the impacts of Navy acoustic stressors on ESA-listed cetaceans.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the Navy should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

14 REINITIATION OF CONSULTATION

This concludes formal consultation on the Navy's proposed Phase III MITT activities and NMFS' promulgation of regulations and issuance of incidental take authorizations pursuant to the MMPA. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the ITS is exceeded.

(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.

(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.

(4) A new species is listed, or critical habitat designated under the ESA that may be affected by the action.

15 REFERENCES

Abecassis, M., and coauthors. 2013. A model of loggerhead sea turtle (*Caretta caretta*) habitat and movement in the oceanic North Pacific. PloS one 8(9):e73274.

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.

Academies, N. R. C. o. t. N. 2008. Tackling marine debris in the 21st Century. Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts.

Acebes, J. M. V., J. Darling, and M. Yamaguchi. 2007. Status and distribution of humpback whales (Megaptera novaeangliae) in northern Luzon, Philippines. Journal of Cetacean Research and Management 9(1):37.

Acevedo-Whitehouse, K., A. Rocha-Gosselin, and D. Gendron. 2010. A novel non-invasive tool for disease surveillance of free-ranging whales and its relevance to conservation programs. Animal Conservation 13(2):217-225.

Acevedo, A. 1991. Interactions between boats and bottlenose dolphins, Tursiops truncatus, in the entrance to Ensenada de la Paz, Mexico. Aquatic Mammals 17(3):120-124.

Ackerman, R. A. 1997. The nest environment and the embryonic development of sea turtles. Pages 83-106 *in* P. L. M. Lutz, J. A. , editor. The Biology of Sea Turtles. CRC Press, Boca Raton.

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.

Aguilar Soto, N., and coauthors. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? Marine Mammal Science 22(3):690-699.

Aguilar Soto, N., M. P. Johnson, and P. T. Madsen. 2008. Challenges in population, habitat preference and anthropogenic impact assessment of deep diving cetaceans. Pages 83-92 *in* P. G. H. Evans, editor Workshop at the Twenty-First Annual Meeting of the ECS, San Sebastian Spain.

Allen, A. N., J. J. Schanze, A. R. Solow, and P. L. Tyack. 2014. Analysis of a Blainville's beaked whale's movement response to playback of killer whale vocalizations. Marine Mammal Science 30(1):154-168.

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.)].

Allison, C. 2007. IWC summary catch database. International Whaling Commission.

Alves, A., and coauthors. 2014. Vocal matching of naval sonar signals by long-finned pilot whales (Globicephala melas). Marine Mammal Science 30(3):1248-1257.

Andrady, A. L. 2011. Microplastics in the marine environment. Marine Pollution Bulletin, 62(8), 1596–1605. doi: 10.1016/j.marpolbul.2011.05.030.

André, M., M. Terada, and Y. Watanabe. 1997. Sperm whale (*Physeter macrocephalus*) behavioural responses after the playback of artificial sounds. Report of the International Whaling Commission 47:499-504.

Angradi, A. M., C. Consiglio, and L. Marini. 1993. Behaviour of striped dolphins (*Stenella coeruleoalba*) in the central Tyrrhenian Sea in relation to commercial ships. European Research on Cetaceans 7:77-79. Proceedings of the Seventh Annual Conference of the European Cetacean Society, Inverness, Scotland, 18-21 February.

Anthony, K. R. N., and O. Hoegh Guldberg. 2003. Variation in coral photosynthesis, respiration and growth characteristics in contrasting light microhabitats: An analogue to plants in forest gaps and understoreys? Functional Ecology 17(2):246-259.

Anthony, K. R. N., D. I. Kline, G. Diaz-Pulido, S. Dove, and O. Heogh-Guldberg. 2008. Ocean acidification causes bleaching and productivity loss in coral reef builders. Proceedings of the National Academy of Sciences of the United States of America 105(45):17442–17446.

Antonelis, G. A., J. D. Baker, T. C. Johanos, R. C. Braun, and A. L. Harting. 2006. Hawaiian monk seal (*Monachus schauinslandi*): status and conservation issues. Atoll Research Bulletin 543:75-101.

Antunes, R., and coauthors. 2014. High thresholds for avoidance of sonar by free-ranging long-finned pilot whales (Globicephala melas). Marine Pollution Bulletin 83(1):165-180.

Arcangeli, A., and R. Crosti. 2009. The short-term impact of dolphin-watching on the behaviour of bottlenose dolphins (*Tursiops truncatus*) in western Australia. Journal of Marine Animals and their Ecology 2(1):3-9.

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.

Ashe, E., J. Wray, C. R. Picard, and R. Williams. 2013. Abundance and survival of Pacific humpback whales in a proposed critical habitat area. PloS one 8(9):e75228.

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, D., and W. Perryman. 1982. Movement and speed of dolphin schools responding to an approaching ship. Fishery Bulletin 80:371-379.

Au, W. W. L., and M. Green. 2000. Acoustic interaction of humpback whales and whale-watching boats. Marine Environmental Research 49(5):469-481.

Au, W. W. L., J. Mobley, W. C. Burgess, M. O. Lammers, and P. E. Nachtigall. 2000a. Seasonal and diurnal trends of chorusing humpback whales wintering in waters off western Maui. Marine Mammal Science 16(3):15.

Au, W. W. L., and coauthors. 2006. Acoustic properties of humpback whale songs. Journal of Acoustical Society of America 120(August 2006):1103-1110.

Au, W. W. L., A. N. Popper, and R. R. Fay. 2000b. Hearing by whales and dolphins. Springer-Verlag, New York.

Avens, L., and K. J. Lohmann. 2003. Use of multiple orientation cues by juvenile loggerhead sea turtles, *Caretta caretta*. Journal of Experiential Biology 206(23):4317–4325.

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.

Ayres, K. L., and coauthors. 2012. Distinguishing the impacts of inadequate prey and vessel traffic on an endangered killer whale (Orcinus orca) population. PloS one 7(6):e36842.

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.

Bailey, H., and coauthors. 2009. Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. Endangered Species Research 10:93-106.

Bain, D. E. 2002. A model linking energetic effects of whale watching to killer whale (Orcinus orca) population dynamics. Friday Harbor Laboratories, University of Washington, Friday Harbor, Washington.

Baird, A. H., J. R. Guest, and B. L. Willis. 2009. Systematic and biogeographical patterns in the reproductive biology of scleractinian corals. Annual Review of Ecology, Evolution, and Systematics 40:551-571.

Baird, R. W., and coauthors. 2013. Odontocete Studies Off the Pacific Missile Range Facility in February 2013: Satellite-Tagging, Photo Identification, and Passive Acoustic Monitoring for Species Verification. U.S. Navy Pacific Fleet.

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, phot-identification, and passive acoustic monitoring. .

Baird, R. W., and coauthors. 2016. Final Report: Odontocete Studies on the Pacific Missile Range Facility in February 2015: Satellite-Tagging, Photo-Identification, and Passive Acoustic Monitoring. In U. S. P. F. Commander (Ed.), Naval Facilities Engineering Command Pacific under HDR Environmental, Operations and Construction, Inc. Contract No. N62470-10-D-3011, CTO KB28. Olympia, WA: HDR Inc.

Bak, R. P. M. 1978. Lethal and sublethal effects of dredging on reef corals. Marine Pollution Bulletin 9(1):14-16.

Bak, R. P. M., and J. H. B. W. Elgershuizen. 1976. Patterns of oil-sediment rejection in corals. Marine Biology 37(2):105-113.

Baker, C. S., and L. M. Herman. 1983. Seasonal contrasts in the social behavior of the North Pacific humpback whale. Pages 5 *in* Fifth Biennial Conference on the Biology of Marine Mammals, New England Aquarium, Boston, Massachusetts.

Baker, C. S., and L. M. Herman. 1989. Behavioral responses of summering humpback whales to vessel traffic: Experimental and opportunistic observations (*Megaptera novaeangliae*). Tech. Rep. No. NPS-NR-TRS-89-01. 50 pgs. Final report to the National Park Service, Alaska Regional Office, Anchorage, Alaska [Available from the U.S. Dept. Interior, NPS, Alaska Reg. Off., Room 107, 2525 Gambell St., Anchorage, AK 99503.

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 in southeast Alaska: 1982 season. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory.

Baker, C. S., and coauthors. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Marine Ecology Progress Series 494:291-306.

Baker, J. D., C. L. Littnan, and D. W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 2:21-30.

Balazs, G. H. 1995. Status of sea turtles in the central Pacific Ocean. Pages 243-252 *in* K. A. Bjorndal, editor. Biology and Conservation of Sea Turtles, Revised edition. Smithsonian Institution Press, Washington, DC.

Balazs, G. H., and M. Chaloupka. 2004. Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. Biological Conservation 117(5):491-498.

Baracho-Neto, C. G., and coauthors. 2012. Site fidelity and residence times of humpback whales (Megaptera novaeangliae) on the Brazilian coast. Marine Biological Association of the United Kingdom. Journal of the Marine Biological Association of the United Kingdom 92(8):1783.

Baraff, L., and M. T. Weinrich. 1993. Separation of humpback whale mothers and calves on a feeding ground in early autumn. Marine Mammal Science 9(4):431-434.

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.

Barendse, J., P. B. Best, I. Carvalho, and C. Pomilla. 2013. Mother knows best: Occurrence and associations of resighted humpback whales suggest maternally derived fidelity to a Southern Hemisphere coastal feeding ground. PloS one 8(12):e81238.

Barlow, J. 2016. Cetacean abundance in the California current estimated from ship-based line-transect surveys in 1991-2014. NMFS, Southwest 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. 2014. Evaluating the impacts of marine debris on cetaceans. Marine Pollution Bulletin 80(1-2):210-221.

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(5 Part 2):2197-2209.

Baumgartner, M. F., and coauthors. 2008. Low frequency vocalizations attributed to sei whales (*Balaenoptera borealis*). Journal of the Acoustical Society of America 124(2):1339-1349.

Beale, C. M., and P. Monaghan. 2004. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41:335-343.

Beamish, R. J. 1993. Climate and exceptional fish production off the west coast of North American. Canadian Journal of Fisheries and Aquatic Sciences 50(10):2270-2291.

Becker, S. L., R. E. Brainard, and K. S. Van Houtan. 2019. Densities and drivers of sea turtle populations across Pacific coral reef ecosystems. PloS one 14(4):e0214972.

Bejder, L., and coauthors. 2019. Low energy expenditure and resting behaviour of humpback whale mother-calf pairs highlights conservation importance of sheltered breeding areas. Scientific Reports 9(1):771.

Benson, A., and A. W. Trites. 2002. Ecological effects of regime shifts in the Bering Sea and eastern North Pacific Ocean. Fish and Fisheries 3(2):95-113.

Benson, S. R., and coauthors. 2007. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6(1):150-154.

Benson, S. R., and coauthors. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7):1-27.

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.

Bergström, L., and coauthors. 2014. Effects of offshore wind farms on marine wildlife—a generalized impact assessment. Environmental Research Letters 9(3):034012.

Berini, C. R., L. M. Kracker, and W. E. Mcfee. 2015. Modeling pygmy sperm whale (Kogia breviceps, De Blainville 1838) strandings along the southeast coast of the United States from 1992 to 2006 in relation to environmental factors. National Oceanic and Atmospheric Administration, National Ocean Service.

Bernaldo De Quiros, Y., and coauthors. 2012. Decompression vs. decomposition: Distribution, amount, and gas composition of bubbles in stranded marine mammals. Frontiers in Zoology 3:177.

Bernaldo De Quiros, Y., and coauthors. 2013. Compositional discrimination of decompression and decomposition gas bubbles in bycaught seals and dolphins. PloS one 8(12):e83994.

Bettridge, S., and coauthors. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Binckley, C. A., J. R. Spotila, K. S. Wilson, and F. V. Paladino. 1998. Sex determination and sex ratios of Pacific leatherback turtles, *Dermochelys coriacea*. Copeia 2(291-300).

Birney, K., and coauthors. 2015. Report on the 2014 Vessel Speed Reduction Incentive Trial in the Santa Barbara Channel. National Marine Sanctuaries Channel Islands, Santa Barbara County Air Pollution Control District, Environmental Defense Center, and the National Marine Sanctuary Foundation, Santa Barbara, CA.

Birrell, C. L., L. J. McCook, and B. L. Willis. 2005. Effects of algal turfs and sediment on coral settlement. Marine Pollution Bulletin 51(1-4):408-414.

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.

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.

Blane, J. M., and R. Jaakson. 1994. The impact of ecotourism boats on the St. Lawrence beluga whales (*Delphinapterus leucas*). Environmental Conservation 21(3):267-269.

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.

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.

Bothwell, A. M. 1981. Fragmentation, a means of asexual reproduction and dispersal in the coral genus Acropora (Scleractinia: Astrocoeniida: Acroporidae) – A preliminary report. Prceedings of the Fouth International Coral Reef Symposium, Manila, 1981, Vol. 2: 137-144.

Bowen, B. W., and coauthors. 1995. Trans-Pacific migrations of the loggerhead turtle (*Caretta caretta*) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Science 92:3731-3734.

Bowles, A. E., M. Smultea, B. Wursig, D. P. Demaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island feasibility test. Journal of the Acoustical Society of America 96(4):2469-2484.

Boyd, I., D. Claridge, C. Clark, B. Southall, and P. Tyack. 2008. Behavioral Response Study 2007 BRS-07 cruise report.

Boyle, M. C., and coauthors. 2009. Evidence for transoceanic migrations by loggerhead sea turtles in the southern Pacific Ocean. Proceedings of the Royal Society B-Biological Sciences 276(1664):1993-1999.

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).

Bradshaw, C. J. A., K. Evans, and M. A. Hindell. 2006. Mass cetacean strandings—A plea for empiricism. Conservation Biology 20(2):584–586.

Brainard, R. E., and coauthors. 2011. Status review report of 82 candidate coral species petitioned under the U.S. Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.

Braithwaite, J. E., J. J. Meeuwig, and M. R. Hipsey. 2015. Optimal migration energetics of humpback whales and the implications of disturbance. Conservation Physiology 3(1):cov001.

Branch, T. A. 2007. Abundance of Antarctic blue whales south of 60 S from three complete circumpolar sets of surveys. Journal of Cetacean Research and Management 9(3):253-262.

Brandt, M. J., A. Diederichs, K. Betke, and G. Nehls. 2011. Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. Marine Ecology Progress Series 421:205–216.

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.

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.

Brindock, K. 2013. Sea Turtle Monitoring Naval Base Guam.

Browning, L. J., and E. J. Harland. 1999. Are bottlenose dolphins disturbed by fast ferries? European Research on Cetaceans 13:92-98. Proceedings of the thirteenth Annual Conference of the European Cetacean Society. P. G. H. Evans, J. Cruz & J. A. Raga-Eds.). Valencia, Spain, 5-8 April.

Brumm, H., and H. Slabbekoorn. 2005. Acoustic communication in noise. Advances in the Study of Behavior 35:151-209.

Bryant, P. J., C. M. Lafferty, and S. K. Lafferty. 1984. Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. (*Eschrichtius robustus*). M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The Gray Whale, *Eschrichtius robustus*. Academic Press, New York.

Bugoni, L., L. Krause, and M. Virginia Petry. 2001. Marine debris and human impacts on sea turtles in southern Brazil. Marine Pollution Bulletin 42(12):pp. 1330-1334.

Bullock, T. H., D. A. Bodznick, and R. G. Northcutt. 1983. The phylogenetic distribution of electroreception - evidence for convergent evolution of a primitive vertebrate sense modality. Brian Research Reviews 6(1):25-46.

Bunn, N. A., C. J. Fox, and T. Webb. 2000. A literature review of studies on fish egg mortality: implications for the estimation of spawning stock biomass by the annual egg production method. Centre for Environment, Fisheries and Aquaculture Science, 111.

Burtenshaw, J. C., and coauthors. 2004. Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. Deep-Sea Research II 51:967-986.

Calambokidis, J., and J. Barlow. 2013. Updated abundance estimates of blue and humpback whales off the U.S. west coast incorporating photo-identifications from 2010 and 2011. Final Report for contract AB-133F-10-RP-0106. Cascadia Research, PSRG-2013-13R, Olympia, Washington.

Calambokidis, J., J. Barlow, J. K. B. Ford, T. E. Chandler, and A. B. Douglas. 2009a. Insights into the population structure of blue whales in the eastern North Pacific from recent sightings and photographic identification. Marine Mammal Science 25(4):816-832.

Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Jessie Huggins. 2009b. 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.

Calambokidis, J., and coauthors. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific U.S. Dept of commerce, Western Administrative Center, Seattle, Washington.

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.

Campbell, G. S., D. W. Weller, and J. A. Hildebrand. 2010. SIO small boat based marine mammal surveys in Southern California: Report of Results for August 2009–July 2010: Annual Range Complex Monitoring Report for Hawaii and Southern California. Draft submission to NMFS 15 September 2010. U.S. Department of the Navy.

Capella, J., L. Flórez-González, and G. Bravo. 1995. Site fidelity and seasonal residence of humpback whales around Isla Gorgona, a breeding ground in the Colombian Pacific. Pages 14-18 *in* Eleventh Biennial Conference on the Biology of Marine Mammals.

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.

Carilli, J., S. H. Smith, D. Marx Jr, L. Bolick, and D. Fenner. 2018. Farallon De Medinilla 2017 Species Level Coral Reef Survey Report. SSC Pacific San Diego United States.

Carillo, M., and F. Ritter. 2010. Increasing numbers of ship strikes in the Canary Islands: Proposals for immediate action to reduce risk of vessel-whale collisions. International Whaling Commission Scientific Committee, Santiago, Chile.

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.

Carpenter, K. E., and coauthors. 2008. One-third of reef-building corals face elevated extinction risk from climate change and local impacts. Science 321(5888):560-563.

Carretta, J. V., and J. Barlow. 2008. Acousitc pingers eliminate beaked whale bycatch in a gill net fishery. Marine Mammal Science 24(4):2053-2073.

Carretta, J. V., and coauthors. 2016. Recovery rates of bottlenose dolphin (Tursiops truncatus) carcasses estimated from stranding and survival rate data. Marine Mammal Science 32(1):349-362.

Carretta, J. V., and coauthors. 2017. U.S. Pacific Marine Mammal Stock Assessments: 2016, NOAA-TM-NMFS-SWFSC-577.

Carretta, J. V., and coauthors. 2013. U.S. Pacific marine mammal stock assessments: 2012. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., and coauthors. 2014. U. S. Pacific marine mammal stock assessments, 2013. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., Oleson, E.M., Weller, D.W., Lang, A.R., Forney, K.A., Baker, J.D., Hanson, B., Martien, K.K., Muto, M., Orr, A.J. and Huber, H.R. 2019. U.S. Pacific marine mammal stock assessments. U.S. Department of Commerce.

Cartwright, R., and M. Sullivan. 2009. Behavioral ontogeny in humpback whale (Megaptera novaeangliae) calves during their residence in Hawaiian waters. Marine Mammal Science 25(3):659-680.

Cartwright, R., and coauthors. 2019. Fluctuating reproductive rates in Hawaii's humpback whales, Megaptera novaeangliae, reflect recent climate anomalies in the North Pacific. Royal Society Open Science 6(3):181463.

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. 2006. Evoked potential audiograms of the nurse shark (*Ginglymostoma cirratum*) and the yellow stingray (*Urobatis jamaicensis*). Environmental Biology of Fishes 76:101-108.

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.

Castellote, M., C. W. Clark, and M. O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. Biological Conservation 147(1):115-122.

Cattanach, K. L., J. Sigurjonsson, S. T. Buckland, and T. Gunnlaugsson. 1993. Sei whale abundance in the North Atlantic, estimated from NASS-87 and NASS-89 data. Report of the International Whaling Commission 43:315-321.

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.

Chaloupka, M., P. Dutton, and H. Nakano. 2004. Status of sea turtle stocks in the Pacific. Pages 135-164 *in* Expert Consultation on Interactions Between Sea Turtles and Fisheries within an Ecosystem Context, volume FAO Fisheries Report. No. 738, Rome.

Chaloupka, M., T. M. Work, G. H. Balazs, S. K. K. Murakawa, and R. Morris. 2008. Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago (1982-2003). Marine Biology 154(5):887-898.

Charif, R., and coauthors. 2015. Development of Statistical Methods for Assessing Changes in Whale Vocal Behavior in Response to Mid-Frequency Active Sonar. Final Report. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-10-3011, Task Order 39, issued to HDR Inc., Virginia Beach, Virginia. 20 March 2015.

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.

Chen, C., T. Leu, S. Joung, and N. Lo. 1990. Age and growth of the scalloped hammerhead, Sphyrna lewini, in northeastern Taiwan waters.

Chiba, S., and coauthors. 2018. Human footprint in the abyss: 30 year records of deep-sea plastic debris. Marine Policy 96:204–212.

Childers, A. R., T. E. Whitledge, and D. A. Stockwell. 2005. Seasonal and interannual variability in the distribution of nutrients and chlorophyll a across the Gulf of Alaska shelf: 1998-2000. Deep-Sea Research II 52:193-216.

Chittleborough, R. 1955. Aspects of reproduction in the male humpback whale, Megaptera nodosa (Bonnaterre). Marine and Freshwater Research 6(1):1-29.

Cholewiak, D., and coauthors. 2018. Communicating amidst the noise: Modeling the aggregate influence of ambient and vessel noise on baleen whale communication space in a national marine sanctuary. Endangered Species Research 36:59–75.

Cholewiak, D., A. I. Deangelis, D. Palka, P. J. Corkeron, and S. M. Van Parijs. 2017. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. Royal Society Open Science 4(12).

Christian, E., and J. Gaspin. 1974. Swimmer Safe Standards from Underwater Explosions. Navy Science Assistance Program Project No. PHP-11-73. White Oak, MD: Naval Ordnance Laboratory.

Christiansen, F., A. M. Dujon, K. R. Sprogis, J. P. Y. Arnould, and L. Bejder. 2016a. Noninvasive unmanned aerial vehicle provides estimates of the energetic cost of reproduction in humpback whales. Ecosphere, 7(10), e01468. .

Christiansen, F., D. Lusseau, E. Stensland, and P. Berggren. 2010. Effects of tourist boats on the behaviour of Indo-Pacific bottlenose dolphins off the south coast of Zanzibar. Endangered Species Research 11(1):91-99.

Christiansen, F., and coauthors. 2016b. Spatial variation in directional swimming enables juvenile sea turtles to reach and remain in productive waters. Marine Ecology Progress Series, 557, 247–259. .

Chua, T. H. 1988. On the road to extinction: The leatherback turtle (*Dermochelys coriacea*) in Terengganu, Malaysia. Pages 153-158 *in* A. Sasekumar, R. D'Cruz, and S. L. H. Lim, editors. Eleventh Annual Seminar, Malaysian Society of Marine Sciences, Kuala Lumpur, Malaysia.

Clapham, P. J., and C. A. Mayo. 1987. Reproduction and recruitment of individually identified humpback whales, *Megaptera novaeangliae*, observed in Massachusetts Bay, 1979-1985. Canadian Journal of Zoology 65:2853-2863.

Clapham, P. J., and C. A. Mayo. 1990. Reproduction of humpback whales (*Megaptera novaeangliae*) observed in the Gulf of Maine. Report of the International Whaling Commission Special Issue 12:171-175.

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. 2009. 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 P. J. Clapham. 2004. Acoustic monitoring on a humpback whale (Megaptera novaeangliae) feeding ground shows continual singing into late spring. Proceedings of the Royal Society of London Series B Biological Sciences 271(1543):1051-1057.

Clark, C. W., and K. M. Fristrup. 2001. Baleen whale responses to low-frequency human-made underwater sounds. Journal of the Acoustical Society of America 110(5 Part 2):2751.

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, H. R., and C. J. Gobler. 2016. Diurnal fluctuations in CO_2 and dissolved oxygen concentrations do not provide a refuge from hypoxia and acidification for early-life-stage bivalves. Marine Ecology Progress Series 558:1–14.

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.

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*.

Collin, S. P., and D. L. Whitehead. 2004. The functional roles of passive electroreception in non-electric fishes. Animal Biology 54(1):25-Jan.

Coma, R., and H. R. Lasker. 1997. Small-scale heterogeneity of fertilization success in a broadcast spawning octocoral. Journal of Experimental Marine Biology and Ecology 214(1-2):107-120.

Commerce. 2001. Joint Interim Report Bahamas Marine Mammal Stranding Event of 15–16 March 2000. Washington, DC: U.S. Department of Commerce, & U.S. Department of the Navy. .

Commonwealth Ports Authority. 2005. CommonWealth Ports Authority. http://www.cpa.gov.mp/default.asp.

Commonwealth Ports Authority. 2010. Commonwealth Ports Authority report on the audit of financial statements in accordance with OMB circular A-133 year ended September 30, 2009.

Compagno, J. V. L. 1984. FAO species catalogue Vol.4, part 2 sharks of the world: An annotated and illustrated catalogue of shark species known to date. Food and Agriculture Organization of the United Nations.

Conant, T. A., and coauthors. 2009. Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

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.

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. J. 1995. Humpback whales (*Megaptera novaeangliae*) in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. Canadian Journal of Zoology 73(7):1290-1299.

COSEWIC. 2002. COSEWIC assessment and update status report on the blue whale *Balaenoptera musculus* (Atlantic population, Pacific population) in Canada. COSEWIC,

Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 37p. Available at: www.sararegistry.gc.ca/status/status_e.cfm.

Costa, D., and coauthors. 2016a. A bioenergetics approach to understanding the population consequences of disturbance: elephant seals as a model system The Effects of Noise on Aquatic Life II (pp. 116–169). New York: Springer.

Costa, D. P., and coauthors. 2016b. Assessing the exposure of animals to acoustic disturbance: Towards an understanding of the population consequences of disturbance.

Costidis, A. M., and S. A. Rommel. 2016. The extracranial venous system in the heads of beaked whales, with implications on diving physiology and pathogenesis. Journal of Morphology 277(1):34-64.

Council, W. P. R. F. M. 2011. Mariana Archipelago Fishery Ecosystem Plan 2009 Annual Report, Honolulu, Hawaii.

Courbis, S., and G. Timmel. 2008. Effects of vessels and swimmers on behavior of Hawaiian spinner dolphins (Stenella longirostris) in Kealakeakua, Honaunau, and Kauhako bays, Hawaii. Marine Mammal Science, 25(2), 1–11. .

Cox, T. M., and coauthors. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3):177-187.

Craig, A. S., L. M. Herman, A. A. Pack, and James O. Waterman. 2014. Habitat segregation by female humpback whales in Hawaiian waters: avoidance of males? Behaviour 151(5):613-631.

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.

Crawford, J. D., and X. Huang. 1999. Communication signals and sound production mechanisms of mormyrid electric fish. Journal of Experimental Biology 202:1417-1426.

Croll, D., and coauthors. 1999a. From wind to whales: Foraging ecology of rorquals in the California Current. Thirteen Biennial Conference on the Biology of Marine Mammals, 28 November - 3 December Wailea Maui HI. p.41.

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.

Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999b. Marine vertebrates and low frequency sound. Technical report for LFA EIS, 28 February 1999. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California Santa Cruz. 437p.

Crum, L., and Y. Mao. 1996. Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. Acoustical Society of America 99(5):2898-2907.

Crum, L. A., and coauthors. 2005. Monitoring bubble growth in supersaturated blood and tissue ex vivo and the relevance to marine mammal bioeffects. Acoustics Research Letters Online 6(3):214-220.

Culik, B. M. 2004. Review of small cetaceans. Distribution, behaviour, migration and threats. United Nations Environment Programme.

Culik, B. M., S. Koschinski, N. Tregenza, and G. Ellis. 2001. Reactions of harbor porpoises Phocoena phocoena and herring Clupea harengus to acoustic alarms. Marine Ecology Progress Series 211:255-260.

Cummings, W. C., and P. O. Thompson. 1971a. Gray whales, Eschrichtius robustus, avoid the underwater sounds of killer whales, Orcinus orca. Fishery Bulletin 69(3):525-530.

Cummings, W. C., and P. O. Thompson. 1971b. 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.

Cure, C., and coauthors. 2012. Pilot whales attracted to killer whale sounds: Acoustically-mediated interspecific interactions in cetaceans. PloS one 7(12):e52201.

Cure, C., and coauthors. 2015. Predator sound playbacks reveal strong avoidance responses in a fight strategist baleen whale. Marine Ecology Progress Series 526:267-282.

Curtis, K. A., J. E. Moore, and S. R. Benson. 2015. Estimating limit reference points for western Pacific leatherback turtles (Dermochelys coriacea) in the US West Coast EEZ. PloS one 10(9):e0136452.

D'Vincent, C. G., R. M. Nilson, and R. E. Hanna. 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. Scientific Reports of the Whales Research Institute 36:41-47.

Dähne, M., and coauthors. 2014. Marine mammals and windfarms: effects of alpha ventus on harbour porpoises. Pages 133–149 *in* Ecological Research at the Offshore Windfarm alpha ventus. Springer.

Dallmeyer, D. G., J. W. Porter, and G. J. Smith. 1982. Effects of particulate peat on the behavior and physiology of the Jamaican reef-building coral *Montastrea annularis*. Marine Biology 68(3):229-233.

Danil, K., and J. A. St. Leger. 2011. Seabird and dolphin mortality associated with underwater detonation exercises. Marine Technology Society Journal 45(6):89-95.

Danilewicz, D., M. Tavares, I. B. Moreno, P. H. Ott, and C. C. Trigo. 2009. Evidence of feeding by the humpback whale (Megaptera novaeangliae) in mid-latitude waters of the western South Atlantic. JMBA2 - Biodiversity Records-Published Online 3Pgs.

Darling, J. D., M. E. Jones, and C. P. Nicklin. 2006. Humpback whale songs: Do they organize males during the breeding season? Behaviour 143(9):1051-1101.

David, L. 2002. Disturbance to Mediterranean cetaceans caused by vessel traffic. Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies. G. Notarbartolo de Sciara (ed.). Section 11. 21pp. A report to the ACCOBAMS Secretariat, Monaco, February.

Davison, P., and R. G. Asch. 2011. Plastic ingestion by mesopelagic fishes in the North Pacific Subtropical Gyre. Marine Ecological Progress Series 432:173-180.

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.

Dear, J. J. F., D. A. Carder, C. E. Schlundt, and R. L. 2010. Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. Journal of the Acoustical Society of America 127(5):3256-3266.

Deecke, V. B., P. J. B. Slater, and J. K. B. Ford. 2002. Selective habituation shapes acoustic predator recognition in harbour seals. Nature 417(6912):171-173.

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.

Denkinger, J., and coauthors. 2013. Are boat strikes a threat to sea turtles in the Galapagos Marine Reserve? Ocean & coastal management 80:29-35.

Dennison, S., and coauthors. 2011. Bubbles in live-stranded dolphins. Proceedings of the Royal Society B. Biological Sciences, 10.

Deruiter, S., and coauthors. 2013a. Responses of Cuvier's beaked whales to controlled and incidental exposure to mid-frequency active (MFA) sonar sounds. Pages 50-51 *in* Twenty-Seventh Annual Conference of the European Cetacean Society, Setubal, Portugal.

Deruiter, S. L., and coauthors. 2013b. Delphinid whistle production and call matching during playback of simulated military sonar. Marine Mammal Science 29(2):E46-E59.

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.

Deruiter, S. L., and coauthors. 2013c. First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. Biology Letters 9(4):Article 20130223.

Di Lorio, L., and C. W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters 6:51–54.

Dierauf, L., and M. Gulland. 2001. Marine mammal unusual mortality events. Pages 69-81 *in* CRC Handbook of Marine Mammal Medicine. CRC Press.

DoN. 2003a. Final Environmental Assessment Inner Apra Harbor Maintenance Dredging Guam.

DON. 2003b. Integrated natural resources management plan--Farallon de Medinilla and Tinian military lease areas--Commonwealth of the Northern Mariana Islands. Plan duration: FY 03-12. Department of the Navy, U.S. Naval Forces Marianas, Commander.

DoN. 2005. Year 2004 assessment: Marine and fisheries resources, Farallon De Medinilla, Commonwealth of the Northern Mariana Islands. Department of the Navy.

DoN. 2010a. Final environmental impact statement: Guam and CNMI military relocation. Relocating Marines from Okinawa, visiting aircraft carrier berthing, and army air and missile defense task force. Department of the Navy, Naval Facilities Engineering Command, Pacific, Joint Guam Program Office, Pearl Harbor, Hawaii.

DoN. 2010b. Mariana Islands Range Complex EIS/OEIS. Department of the Navy.

DoN. 2013. Annual report: Wildlife surveys on Tinian and FDM. Department of the Navy.

DON. 2019. Integrated Natural Resources Management Plan for Joint Region Marianas. Final., Honolulu, Hawaii.

Doney, S. C., and coauthors. 2012. Climate change impacts on marine ecosystems. Marine Science 4(1):11-37.

Dow, W. E., D. A. Mann, T. T. Jones, S. A. Eckert, and C. A. Harms. 2008. In-water and in-air hearing sensitivity of the green sea turtle (Chelonia mydas). 2nd International Confernece on Acoustic Communication by Animals, Corvalis, OR.

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):33-46.

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.

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., and coauthors. 2013. Multivariate analysis of behavioural response experiments in humpback whales (Megaptera novaeangliae). Journal of Experimental Biology 216(5):759-770.

Dunlop, R. A. 2016. The effect of vessel noise on humpback whale, *Megaptera novaeangliae*, communication behaviour. Animal Behaviour 111:13–21.

Dunlop, R. A. 2019. The effects of vessel noise on the communication network of humpback whales. Royal Society Open Science 6(11):190967.

Dunlop, R. A., D. Cato, and M. J. Noad. 2010. Your attention please: increasing ambient noise levels elictis a change in communication behaviour in humpback whales (Megoptera novaeangliae). Proceedings of the Royal Society B, 277, 2521–2529. .

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2008. Non-song acoustic communication in migrating humpback whales (*Megaptera novaeangliae*). Marine Mammal Science 24(3):613-629.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2014. Evidence of a Lombard response in migrating humpback whales (Megaptera novaeangliae). Journal of the Acoustical Society of America 136(1):430-437.

Dunlop, R. A., and coauthors. 2015. The behavioural response of humpback whales (*Megaptera novaeangliae*) to a 20 cubic inch air gun. Aquatic Mammals 41(4):412.

Dunlop, R. A., and coauthors. 2018. A behavioural dose-response model for migrating humpback whales and seismic air gun noise. Marine Pollution Bulletin 133:506-516.

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.

Dutton, P. H. 2006. Geographic variation in foraging strategies of leatherback populations: A hedge against catastrophy? Pages 189 *in* Twenty-Sixth Annual Conference on Sea Turtle Conservation and Biology.

Dutton, P. H., B. W. Bowen, D. W. Owens, A. Barragan, and S. K. Davis. 1999. Global phylogeography of the leatherback turtle (*Dermochelys coriacea*). Journal of Zoology 248:397-409.

Dutton, P. H., and coauthors. 2007. Status and genetic structure of nesting populations of leatherback turtles (*Dermochelys coriacea*) in the western Pacific. Chelonian Conservation and Biology 6(1):47-53.

Dutton, P. H., and coauthors. 2014a. Population structure and phylogeography reveal pathways of colonization by a migratory marine reptile (*Chelonia mydas*) in the central and eastern Pacific Ecology and Evolution 4(22):4317-4331.

Dutton, P. H., and coauthors. 2014b. Genetic stock structure of green turtle (Chelonia mydas) nesting populations across the Pacific islands. Pacific Science 68(4):451-465.

Dwyer, C. M. 2004. How has the risk of predation shaped the behavioural responses of sheep to fear and distress? Animal Welfare 13(3):269-281.

Eckert, K. L., K. A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly. 1999. Research and management techniques for the conservation of sea turtles. International Union for Conservation of Nature and Natural Resources, Survival Service Commission, Marine Turtle Specialist Group, Blanchard, Pennsylvania.

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

Eckert, K. L., B. P. Wallace, J. G. Frazier, S. A. Eckert, and P. C. H. 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.

Eckert, S. A. 1998. Perspectives on the use of satellite telemetry and electronic technologies for the study of marine turtles, with reference to the first year long tracking of leatherback sea turtles. Pages 44-46 *in* S. P. Epperly, and J. Braun, editors. Proceedings of the 17th Annual Symposium on Sea Turtle Biology and Conservation.

Eckert, S. A. 1999. Habitats and migratory pathways of the Pacific leatherback sea turtle. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

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

Eckert, S. A., and L. Sarti. 1997. Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78:2-7.

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-Walton, P. L., and J. J. Finneran. 2006. Evaluation of Evidence for Altered Behavior and Auditory Deficits in Fishes Due to Human-Generated Noise Sources. Pages 50 *in* U.S. Department of the Navy, editor. SPAWAR Systems Center, San Diego, CA.

Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence estuary. Bioacoustics 1:131-149.

Edds, P. L., and J. A. F. Macfarlane. 1987. Occurrence and general behavior of balaenopterid cetaceans summering in the St. Lawrence Estuary, Canada. Canadian Journal of Zoology 65(6):1363-1376.

Edwards, M. H., and coauthors. 2016. The Hawaii Undersea Military Munitions Assessment. Deep-Sea Research II, 128, 4–13.

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.

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

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.

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.

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.

Environmental Sciences Group. 2005. Canadian Forces Maritime Experimental and Test Ranges (CFMETR) Environmental Assessment Update 2005. Environmental Sciences Group, Royal Military College, RMC-CCE-ES-05-21, Kingston, Ontario.

EPA. 2019. Fact Sheet: Proposed Modification of NPDES Permit No. GUS040000 Municipal Separate Storm Sewer System Department of Navy. U.S. EPA, Region 9, NPDES Permits Section (WTR-2-3), 75 Hawthorne Street, San Francisco, CA 94105-3901

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. 2002a. Hearing abilities of baleen whales. Defence R&D Canada – Atlantic report CR 2002-065. Contract Number: W7707-01-0828. 40pp.

Erbe, C. 2002b. 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. 2015. The maskogram: A tool to illustrate zones of masking. Aquatic Mammals 41(4):434-443.

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.

Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. 2016. Communication masking in marine mammals: A review and research strategy. Marine Pollution Bulletin 103(1–2):15–38.

Eshenroder, R. L., C. R. Bronte, and J. W. Peck. 1994. Comparison of lake trout-egg survival at inshore and offshore and shallow-water and deepwater sites in Lake Superior. Great Lakes Fishery Commission.

Español-Jiménez, S., P. A. Bahamonde, G. Chiang, and V. Häussermann. 2019. Discovering sounds in Patagonia: characterizing sei whale (Balaenoptera borealis) downsweeps in the south-eastern Pacific Ocean. Ocean Science 15(1):75-82.

Evans, P. G. H., and A. Bjørge. 2013. Impacts of climate change on marine mammals. Marine Climate Change Impacts Parternship: Science Review:134-148.

Evans, P. G. H., P. J. Canwell, and E. Lewis. 1992. An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales. European Research on Cetaceans 6:43-46. Proceedings of the Sixth Annual Conference of the European Cetacean Society, San Remo, Italy, 20-22 February.

Evans, P. G. H., and coauthors. 1994. A study of the reactions of harbour porpoises to various boats in the coastal waters of southeast Shetland. European Research on Cetaceans 8:60-64.

Fabricius, K. E., C. Wild, E. Wolanski, and D. Abele. 2003. Effects of transparent exopolymer particles and muddy terrigenous sediments on the survival of hard coral recruits. Estuarine, Coastal and Shelf Science 57(4):613-621.

Fabry, V. J., B. A. Seibel, R. A. Feely, and J. C. Orr. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science 65(3):414–432.

Fahlman, A., S. K. Hooker, A. Szowka, B. L. Bostrom, and D. R. Jones. 2009. Estimating the effect of lung collapse and pulmonary shunt on gas exchange during breath-hold diving: The Scholander and Kooyman legacy. Respiratory Physiology and Neurobiology 165(1):28-39.

Fahlman, A., and coauthors. 2014a. Inflation and deflation pressure-volume loops in anesthetized pinnipeds confirms compliant chest and lungs. Frontiers in Physiology 5.

Fahlman, A., A. Olszowka, B. Bostrom, and D. R. Jones. 2006. Deep diving mammals: Dive behavior and circulatory adjustments contribute to bends avoidance. Respiratory Physiology and Neurobiology 153(1):66-77.

Fahlman, A., P. L. Tyack, P. J. Miller, and P. H. Kvadsheim. 2014b. How man-made interference might cause gas bubble emboli in deep diving whales. Frontiers in Physiology 5:13.

Fair, P. A., and coauthors. 2010. Contaminant blubber burdens in Atlantic bottlenose dolphins (*Tursiops truncatus*) from two southeastern US estuarine areas: Concentrations and patterns of PCBs, pesticides, PBDEs, PFCs, and PAHs. Science of the Total Environment 408(7):1577-1597.

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.

Falcone, E. A., and G. S. Schorr. 2014. Distribution and demographics of marine mammals in SOCAL through photo-identification, genetics, and satellite telemetry: A summary of surveys conducted 1 July 2012 – 30 June 2013. Cascadia Research Collective, Olympia, Washington.

Falcone, E. A., and coauthors. 2009. Sighting characteristics and photo-identification of Cuvier's beaked whales (Ziphius cavirostris) near San Clemente Island, California: A key area for beaked whales and the military? Marine Biology 156(12):2631-2640.

Falcone, E. A., and coauthors. 2017. Diving behaviour of Cuvier's beaked whales exposed to two types of military sonar. Royal Society Open Science 4(170629):1–21.

Falke, K. J., and coauthors. 1985. Seal lungs collapse during free diving: Evidence from arterial nitrogen tensions. Science 229(4713):556-558.

FAO. 2012. Fourth FAO Expert Advisory Panel for the Assessment of Proposals to Amend Appendices I and II of CITES Concerning Commercially-Exploited Aquatic Species. FAO Fisheries and Aquaculture Report No. 1032, Rome.

Farak, A. M., M. W. Richie, J. A. Rivers, and R. K. Uyeyama. 2011. Cruise Report, Marine Species Monitoring and Lookout Effectiveness Study Koa Kai, November 2010, Hawaii Range Complex. Prepared for Commander, U.S. Pacific Fleet.

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.

Fenner, D., and D. R. Burdick. 2016. Field identification guide to the threatened corals of the US Pacific Islands.

Ferguson, M. C., J. Barlow, P. Feidler, S. B. Reilly, and T. Gerrodette. 2006. Spatial models of delphinid (family Delphinidae) encouter rate and group size in the eastern Pacific Ocean. Ecological Modelling 193:645–662.

Fernandez, A., and coauthors. 2005a. Gas and fat embolic syndrome involving a mass stranding of beaked whales (Family Ziphiidae) exposed to anthropogenic sonar signals. Veterinary Pathology 42(4):446-457.

Fernandez, A., P. C. V. Martín, T. Gallardo, and M. Arbel. 2006. New beaked whale mass stranding in Canary Islands associated with naval military exercises (Majestic Eagle 2004). International Policy Workshop on Sound and Marine Mammals, London, England.

Fernandez, A., and coauthors. 2005b. New gas and fat embolic pathology in beaked whales stranded in the Canary Islands. Pages 90 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Ferretti, F., B. Worm, G. L. Britten, M. R. Heithaus, and H. K. Lotze. 2010. Patterns and ecosystem consequences of shark declines in the ocean. Ecology letters 13(8):1055-1071.

Fields, R. 2007. The Shark's Electric Sense: An astonishingly sensitive detector of electric fields helps sharks zero in on prey. Scientific American, Inc.

Filadelfo, R., and coauthors. 2009a. Correlating military sonar use with beaked whale mass strandings: What do the historical data show? Aquatic Mammals 35(4):435-444.

Filadelfo, R., and coauthors. 2009b. Correlating whale strandings with Navy exercises off southern California. Aquatic Mammals 35(4):445-451.

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., D. Carder, C. Schlundt, and R. Dear. 2010. Temporary threshold shift in a bottlenose dolphin (Tursiops truncatus) exposed to intermittent tones. The Journal of Acoustical Society of America, 127(5), 3267–3272. .

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., D. A. Carder, and S. H. Ridgway. 2001. Temporary threshold shift (TTS) in bottlenose dolphins (Tursiops truncatus) exposed to tonal signals. Journal of the Acoustical Society of America 110(5 Part 2):2749.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. Journal of the Acoustical Society of America 118(4):2696-2705.

Finneran, J. J., and C. E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes. SPAWAR Systems Center, San Diego.

Finneran, J. J., and C. E. Schlundt. 2010. Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (Tursiops truncatus). Journal of the Acoustical Society of America 128(2):567-570.

Finneran, J. J., and C. E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (Tursiops truncatus). Journal of the Acoustical Society of America 133(3):1819-1826.

Finneran, J. J., C. E. Schlundt, B. Branstetter, and R. L. Dear. 2007. Assessing temporary threshold shift in a bottlenose dolphin (Tursiops truncatus) using multiple simultaneous auditory evoked potentials. Journal of the Acoustical Society of America 122(2):1249-1264.

Finneran, J. J., and coauthors. 2015. Effects of multiple impulses from a seismic air gun on bottlenose dolphin hearing and behavior. Journal of the Acoustical Society of America 137(4):1634-1646.

Finneran, J. J., C. E. Schlundt, R. Dear, D. A. Carder, and S. H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111(6):2929-2940.

Flower, J. E., and coauthors. 2015. Baseline plasma corticosterone, haematological and biochemical results in nesting and rehabilitating loggerhead sea turtles (*Caretta caretta*). Conservation Physiology 3(1).

Flynn, A., S. Rotmann, and C. Sigere. 2006. Long-term monitoring of coral reefs subject to sediment stress in Papua New Guinea. Pages 286-292 *in* Tenth International Coral Reef Symposium, Okinawa, Japan.

Foote, A. D., R. W. Osborne, and A. R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature 428:910.

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.

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.

Foster, K., and coauthors. 2007. Kilo Wharf Extension Project Marine Assessment and Impact Analysis, Apra Harbor, Guam. Prepared for U.S. Navy Commander Navy Region Marianas, Sumay, Guam

Fournet, M. E. H., and coauthors. 2018a. Humpback whales Megaptera novaeangliae alter calling behavior in response to natural sounds and vessel noise. Marine Ecology Progress Series 607:251-268.

Fournet, M. E. H., L. P. Matthews, C. M. Gabriele, D. K. Mellinger, and H. Klinck. 2018b. Source levels of foraging humpback whale calls. The Journal of the Acoustical Society of America 143(2):EL105-EL111.

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.

Frankel, A. S., and C. W. Clark. 2000. Behavioral responses of humpback whales (Megaptera novaeangliae) to full-scale ATOC signals. Journal of the Acoustical Society of America 108(4):1930-1937.

Frantzis, A., and P. Alexiadou. 2008. Male sperm whale (*Physeter macrocephalus*) coda production and coda-type usage depend on the presence of conspecifics and the behavioural context. Canadian Journal of Zoology 86(1):62-75.

Frazer, L. N., and E. Mercado III. 2000. A sonar model for humpback whale song. IEEE Journal of Oceanic Engineering 25(1):160-182.

Frédou, F. L., and coauthors. 2015. Sharks caught by the Brazilian tuna longline fleet: an overview. Rev. Fish Biol. Fish. 25:365-377.

Frey, A., P. H. Dutton, and G. H. Balazs. 2013. Insights on the demography of cryptic nesting by green turtles (Chelonia mydas) in the main Hawaiian Islands from genetic relatedness analysis. Journal of Experimental Marine Biology and Ecology 442:80-87.

Frid, A. 2003. Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. Biological Conservation 110(3):387-399.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1):11.

Friedlaender, A. S., and coauthors. 2016. Prey-mediated behavioral responses of feeding blue whales in controlled sound exposure experiments. Ecological Applications.

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.

Fromm, D. M. 2009. Reconstruction of acoustic exposure on orcas in Haro Strait.

Fuentes, M. M. P. B., D. A. Pike, A. Dimatteo, and B. P. Wallace. 2013. Resilience of marine turtle regional management units to climate change. Global Change Biology 19(5):1399–1406.

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.

Fulling, G. L., P. H. Thorson, and J. Rivers. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science 65(3):321-343.

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. .

Gabriele, C. M., and A. S. Frankel. 2002. Surprising humpback whale songs in Glacier Bay National Park. Alaska Park Science: Connections to Natural and Cultural Resource Studies in Alaska's National Parks. p.17-21.

Gabriele, C. M., J. M. Straley, and J. L. Neilson. 2007. Age at first calving of female humpback whales in southeastern Alaska. Marine Mammal Science 23(1):226-239.

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., and coauthors. 2016. Behavioural responses of western gray whales to a 4-D seismic survey off northeastern Sakhalin Island, Russia. Endangered Species Research 30:53–71.
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.
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.
Gambell, R. 1976. World whale stocks. Mammal Review 6(1):41-53.
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.
Garcia Parraga, D., M. Moore, and A. Fahlman. 2018. Pulmonary ventilation–perfusion mismatch: a novel hypothesis for how diving vertebrates may avoid the bends.¿Proceedings of the Royal Society B: Biological Sciences,¿285(1877), 20180482. http://doi.org/10.1098/rspb.2018.0482.
Gaspin, J. B. 1975. Experimental Investigations of the Effects of Underwater Explosions on Swimbladder Fish, I: 1973 Chesapeake Bay Tests. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD.
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.
Geijer, C. K. A., and A. J. Read. 2013. Mitigation of marine mammal bycatch in US. fisheries since 1994. Biological Conservation 159:54-60.
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.
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.
Geraci, J., J. Harwood, and V. Lounsbury. 1999. Marine mammal die-offs causes, investigations, and issues. Pages 367-395 *in* R. J. R. Twiss, editor. Conservation and Management of Marine Mammals. Smithsonian Institution Press, Washington, DC.
Geraci, J., and V. Lounsbury. 2005. Marine Mammals Ashore: A Field Guide for Strandings, Second Edition edition. National Aquarium in Baltimore, Baltimore, Maryland.
Germanov, E. S., and coauthors. 2019. Microplastics on the Menu: Plastics Pollute Indonesian Manta Ray and Whale Shark Feeding Grounds. Frontiers in Marine Science 6(679).
Gero, S., H. Whitehead, and L. Rendell. 2016. Individual, unit and vocal clan level identity cues in sperm whale codas. Royal Society Open Science 3(1).
Gill, J. A., K. Norris, and W. J. Sutherland. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation 97:265-268.
Gilman, E. 2008. Pacific leatherback conservation and research activities, financing and priorities. The World Conservation Union and Western Pacific Fishery Management Council and IUCN, Honolulu, Hawaii.
Gilman, E. L. 2009. Guidelines to reduce sea turtle mortality in fishing operations. Food and Agricultural Organization of the United Nations, Rome, Italy.
Gilmour, J. P. 2002. Acute sedimentation causes size-specific mortality and asexual budding in the mushroom coral, *Fungia fungites*. Marine and Freshwater Research 53(4):805-812.

Giorli, G., and W. W. L. Au. 2017. Spatio-temporal variation and seasonality of Odontocetes' foraging activity in the leeward side of the island of Hawaii. Deep-Sea Research I 121:202–209.

Glass, A. H., T. V. N. Cole, and M. Garron. 2010. Mortality and serious injury determinations for baleen whale stocks along the United States and Canadian Eastern Seaboards, 2004-2008. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Glockner-Ferrari, D. A., and M. J. Ferrari. 1985. Individual identification, behavior, reproduction, and distribution of humpback whales, Megaptera novaeangliae, in Hawaii. U.S. Marine Mammal Commission, Washington, D.C.; National Technical Information Service, Springfield, Virginia: 36p.

Godley, B. J., D. R. Thompsonà, 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.

Goertner, J. F. 1982. Prediction of Underwater Explosion Safe Ranges for Sea Mammals. Naval Surface Weapons Center, NSWC TR 82-188, Dahlgren, VA.

Goertner, J. F., M. L. Wiley, G. A. Young, and W. W. McDonald. 1994. Effects of Underwater Explosions on Fish Without Swimbladders. Naval Surface Warfare Center, NSWC TR 88-114, Silver Spring, MD.

Golbuu, Y., S. Victor, E. Wolanski, and R. H. Richmond. 2003. Trapping of fine sediment in a semi-enclosed bay, Palau, Micronesia. Estuarine, Coastal and Shelf Science 57(5-6):941-949.

Goldbogen, J. A., and coauthors. 2013. Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society of London Series B Biological Sciences 280(1765):Article 20130657.

Gomez, C., and coauthors. 2016. A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. Canadian Journal of Zoology.

Gong, Z., and coauthors. 2014. Ecosystem scale acoustic sensing reveals humpback whale behavior synchronous with herring spawning processes and re-evaluation finds no effect of sonar on humpback song occurrence in the Gulf of Maine in fall 2006. PloS one 9(10):e10473.

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 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. 2003a. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal, 37(4), 16–34.

Gordon, J., and coauthors. 2003b. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37(4):16–34.

Graham, E., A. Baird, and S. Connolly. 2008. Survival dynamics of scleractinian coral larvae and implications for dispersal. Coral reefs 27(3):529-539.

Graham, I. M., and coauthors. 2017. Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. Ecosphere 8(5):1–16.

Graham, R. T., and coauthors. 2012. Satellite Tracking of Manta Rays Highlights Challenges to Their Conservation. PloS one 7(5):e36834.

Gregory, L. F., and J. R. Schmid. 2001. Stress response and sexing of wild Kemp's ridley sea turtles (*Lepidochelys kempii*) in the Northeastern Gulf of Mexico. General and Comparative Endocrinology 124:66–74.

Griesser, A., and C. Spillman. 2016. Assessing the skill and value of seasonal thermal stress forecasts for Coral bleaching risk in the Western Pacific. Journal of Applied Meteorology and Climatology 55(7):1565-1578.

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.

Guam, U. D. C. T. o. 2003. Stipulated Order for Preliminary Relief, Civil Case No. 02-00035.

Guest, J., and coauthors. 2010. Rearing coral larvae for reef rehabilitation. Pages ii + 166 pp. *in* A. J. Edwards, editor. Reef Rehabilitation Manual. Coral ReefTargeted Research and Capacity Building for Management Program, St. Lucia, Australia.

Haelters, J., V. Dulière, L. Vigin, and S. Degraer. 2014. Towards a numerical model to simulate the observed displacement of harbour porpoises *Phocoena phocoena* due to pile driving in Belgian waters. Hydrobiologia 756(1):105–116.

Hain, J. H. W., G. R. Carter, S. D. Kraus, C. A. Mayo, and H. E. Winn. 1982. Feeding behavior of the humpback whale, *Megaptera novaeangliae,* in the western North Atlantic. Fishery Bulletin 80(2):259-268.

Hain, J. H. W., and coauthors. 1995. Apparent bottom feeding by humpback whales on Stellwagen Bank. Marine Mammal Science 11(4):464-479.

Hakamada, T., K. Matsuoka, H. Murase, and T. Kitakado. 2017. Estimation of the abundance of the sei whale Balaenoptera borealis in the central and eastern North Pacific in summer using sighting data from 2010 to 2012. Fisheries science 83(6):887-895.

Hall, A. J., and coauthors. 2006. The risk of infection from polychlorinated biphenyl exposure in the harbor porpoise (Phocoena phocoena): A case-control approach. Environmental Health Perspectives 114(5):704-711.

Hall, M. R., M. 2013. Bycatch and non-tuna catch in the tropical tuna purse seine fisheries of the world. . Pages 249 *in* FAO Fisheries and Aquaculture Technical Paper No. 568., Rome.

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, D. J., S. J. Childerhouse, and N. J. Gales. 2010. Mitigating operational interactions between odontocetes and the longline fishing industry: A preliminary global review of the problem and of potential solutions. International Whaling Commission Scientific Committee, Agadir, Morocco.

Hance, A. J., and coauthors. 1982. Hormonal changes and enforced diving in the harbor seal Phoca vitulina. II. Plasma catecholamines. American Journal of Physiology - Regulatory Integrative and Comparative Physiology 242(5):R528-R532.

Hanlon, R. T., and J. B. Messenger. 1996. Cephalopod Behaviour. Cambridge University Press, Cambridge, New York.

Harcourt, R., V. Pirotta, G. Heller, V. Peddemors, and D. Slip. 2014. A whale alarm fails to deter migrating humpback whales: An empirical test. Endangered Species Research 25(1):35-42.

Hare, S. R., and N. J. Mantua. 2001. An historical narrative on the Pacific Decadal Oscillation, interdecadal climate variability and ecosystem impacts. University of Washington.

Hare, S. R., N. J. Mantua, and R. C. Francis. 1999. Inverse production regimes: Alaska and West Coast Pacific salmon. Fisheries 24(1):6-14.

Harrington, F. H., and A. M. Veitch. 1992. Calving success of woodland caribou exposed to low-level jet fighter overflights. Arctic 45(3):213-218.

Harris, C. M., and coauthors. 2019a. Foraging Behavior and Disruption in Blue, Fin, and Humpback Whales in Relation to Sonar Exposure: The Challenges of Generalizing Responsiveness in Species with High Individual Variability. Aquatic Mammals 45(6):646-660.

Harris, C. M., and coauthors. 2019b. 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 L. Thomas. 2015. Status and future of research on the behavioral responses of marine mammals to US. Navy sonar. University of St. Andrews, Centre for Research into Ecological & Environmental Modelling (CREEM).

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.

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., 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.

Harwood, J., and coauthors. 2014. An interim framework for assessing the population consequences of acoustic disturbance. Pages 33 *in* Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014), Amsterdam, The Netherlands.

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.

Hatase, H., and coauthors. 2002a. Population structure of loggerhead turtles, *Caretta caretta*, nesting in Japan: Bottlenecks on the Pacific population. Marine Biology 141:299-305.

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

Hatase, H., and W. Sakamoto. 2004. Forage-diving behaviour of adult Japanese female loggerhead turtles (*Caretta caretta*) inferred from Argos location data. Journal of the Marine Biological Association of the United Kingdom 84:855-856.

Hatase, H., and coauthors. 2002c. Size-related differences in feeding habitat use of adult female loggerhead turtles *Caretta caretta* around Japan determined by stable isotope analyses and satellite telemetry. Marine Ecology Progress Series 233:273-281.

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.

Hatch, L. T., and A. J. Wright. 2007. A brief review of anthropogenic souond in the oceans. International Journal of Comparative Psychology 201(2-3):121-133.

Hawkes, L. A., and coauthors. 2006. Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. Current Biology 16:990–995.

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.

Hayhoe, K., and coauthors. 2018. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (Reidmiller, D.R., et al. [eds.]). U.S. Global Change Research Program, Washington, DC, USA.

Hays, G. C. 2000. The implications of variable remigration intervals for the assessment of population size in marine turtles. J Theor Biol 206(2):221-7.

Hazel, J., and E. Gyuris. 2006. Vessel-related mortality of sea turtles in Queensland, Australia. Wildlife Research 33(2):149-154.

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.

Hazen, E. L., and coauthors. 2012. Predicted habitat shifts of Pacific top predators in a changing climate. Nature Climate Change 3(3):234-238.

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.

HDR. 2011a. Guam marine species monitoring survey vessel-based monitoring surveys winter 2011. HDR.

HDR. 2011b. Jacksonville (JAX) Southeast Anti-Submarine Warfare Integration Training Initiative (SEASWITI) Marine Species Monitoring Aerial Monitoring Surveys Trip Report, 3-5 December 2010. Prepared by HDR Environmental Operations & Construction, Inc. (HDR EOC) under Contract # N62470-10-D-3011.

HDR. 2012. Guam and Saipan marine species monitoring: Winter-spring survey 15-29 March. HDR.

Hearn, A. R., and coauthors. 2014. Elasmobranchs of the Galapagos marine reserve. Pages 23-59 *in* The Galapagos Marine Reserve. Springer.

Helfman, G., B. B. Collette, D. E. Facey, and B. W. Bowen. 2009. The Diversity of Fishes: Biology, Evolution, and Ecology. Wiley.

Helweg, D. A., A. S. Frankel, J. Joseph R. Mobley, and L. M. Herman. 1992. Humpback whale song: Our current understanding. Pages 459-483 *in* J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. Marine Mammal Sensory Systems. Plenum Press, New York.

Henderson, E. E., J. Aschettino, M. Deakos, G. Alongi, and T. Leota. 2019a. Quantifying the Behavior of Humpback Whales (Megaptera novaeangliae) and Potential Responses to Sonar. Aquatic Mammals 45(6):612-631.

Henderson, E. E., J. Aschettino, M. Deakos, G. Alongi, and T. Leota. 2019b. Quantifying the behavior of humpback whales (Megaptera novaeangliae) and potential responses to sonar. Nueva Sociedad (284):612-631.

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). .

Henderson, E. E., and coauthors. 2014. Delphinid behavioral responses to incidental mid-frequency active sonar. Journal of the Acoustical Society of America 136(4-Jan):2003-2014.

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.

Heupel, M., and R. McAuley. 2007. Sharks and Rays (Chondrichthyans) in the North-west Marine Region. Report to Department of the Environment and Water Resources, National Oceans Office Branch. Hobart, Tasmania.

Hewitt, R. P. 1985. Reaction of dolphins to a survey vessel: Effects on census data. Fishery Bulletin 83(2):187-194.

Heyward, A. J., and A. P. Negri. 2012. Turbulence, cleavage, and the naked embryo: a case for coral clones. Science 335:1064.

Hildebrand, J. 2004. Sources of anthropogenic sound in the marine environment. University of California, San Diego, Scripps Institution of Oceanography.

Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Hill, M., A. Ligon, A. Ü, M. Deakos, and E. Oleson. 2013. Cetacean surveys of Guam and CNMI Waters: June – July, 2013. NOAA, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.

Hill, M., and coauthors. 2011. Cetacean surveys of Guam and CNMI waters: August - September, 2011.

Hill, M. C., A. D. Ligon, M. H. Deakos, A. C. Ü, A. Milette-Winfree, A. R. Bendlin, and E. M. Oleson. 2014. Cetacean Surveys in the Waters of the Southern Mariana Archipelago (February 2010–April 2014, Honolulu, HI.

Hill, M. C., and coauthors. 2017. Cetacean monitoring in the Mariana Islands Range Complex, 2016. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-17-002. 46 pp.

Hill, M. C., A. L. Bradford, A. D. Ligon, A. C. Ü, and E. M. Oleson. 2018. Cetacean Monitoring in the Mariana Islands Range Complex, 2017. Pacific Islands Fisheries Science Center, Honolulu, HI.

Hill, M. C., and coauthors. 2016a. Are Humpback Whales (*Megaptera novaeangliae*) Breeding and Calving in the Mariana Islands? International Whaling Commission, SC/66b/O/02, Cambridge, United Kingdom.

Hill, M. C., A. L. Bradford, and E. M. Oleson. 2020a. Preliminary Mark-Recapture Abundance Estimates of Humpback Whales on a Breeding Area in the Mariana Archipelago. Pacific Islands Fisheries Science Center, PIFSC Administrative Report.

Hill, M. C., and coauthors. 2020b. Found: a missing breeding ground for endangered western North Pacific humpback whales in the Mariana Archipelago. Endangered Species Research 41:91-103.

Hill, M. C., E. M. Oleson, A. L. Bradford, K. K. Martien, D. Steel, and C. S. Baker. 2018. Draft Pacific Islands Fisheries Science Center Mariana Archipelago Cetacean Surveys: A Review of Available Data and Analyses Through March 2018. U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI.

Hill, M. C., A. D. Ligon, A. C. U, and E. Oleson. 2019. Cetacean Monitoring in the Mariana Islands Range

Complex, August–September 2018. Pacific Islands Fisheries Science Center, Honolulu, Hawaii.

Hill, M. C., and coauthors. 2016b. Cetacean monitoring in the Mariana Islands Range Complex, 2015. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-16-01. 36 pp.

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.

Hirth, H., J. Kasu, and T. Mala. 1993. Observations on a leatherback turtle *Dermochelys coriacea* nesting population near Piguwa, Papua New Guinea. Biological Conservation 65:77-82.

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

Hochachka, P. W., and coauthors. 1995. Hormonal regulatory adjustments during voluntary diving in Weddell seals. Comparative Biochemistry and Physiology B Biochemistry and Molecular Biology 112(2):361-375.

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., V. Veirs, and S. Veirs. 2008. Investigating noise effects on the call amplitude of endangered Southern Resident killer whales (*Orcinus orca*). Journal of the Acoustical Society of America 123(5 Part 2):2985.

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.

Holt, M. M., D. P. Noren, and C. K. Emmons. 2011. Effects of noise levels and call types on the source levels of killer whale calls. Journal of the Acoustical Society of America 130(5):3100-3106.

Hooker, S. K., R. W. Baird, and A. Fahlman. 2009. Could beaked whales get the bends? Effect of diving behaviour and physiology on modelled gas exchange for three species: Ziphius

cavirostris, Mesoplodon densirostris and Hyperoodon ampullatus. Respiratory Physiology and Neurobiology 167(3):235-246.

Hooker, S. K., and coauthors. 2012. Deadly diving? Physiological and behavioural management of decompression stress in diving mammals. Proceedings of the Royal Society of London Series B Biological Sciences 279(1731):1041-1050.

Hoopes, L. A., A. M. Landry Jr., and E. K. Stabenau. 2000. Physiological effects of capturing Kemp's ridley sea turtles, *Lepidochelys kempii*, in entanglement nets. Canadian Journal of Zoology 78(11):1941–1947.

Hore, P. 2012. Are biochemical reactions affected by weak magnetic fields? Proceedings of the National Academy of Sciences, 109(5), 1357–1358. .

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.

Horwood, J. 2009. Sei whale: *Balaenoptera borealis*. Pages 1001-1003 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals, Second edition. Academic Press, San Diego.

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., R. Howard, and S. Ridgway. 2001a. Can diving behavior increase the chance of acoustically driven bubble growth in marine mammals? Pages 103 *in* Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Houser, D., S. W. Martin, and J. Finneran. 2013. Exposure amplitude and repetition affect bottlenose dolphin behavioral responses t esponses to simulated mid-fr o simulated mid-frequency sonar signals. Journal of Experimental Marine Biology and Ecology 443:123-133.

Houser, D. S., L. A. Dankiewicz-Talmadge, T. K. Stockard, and P. J. Ponganis. 2009. Investigation of the potential for vascular bubble formation in a repetitively diving dolphin. Journal of Experimental Biology 213(1):52-62.

Houser, D. S., D. A. Helweg, and P. W. B. Moore. 2001b. A bandpass filter-bank model of auditory sensitivity in the humpback whale. (Megaptera novaeangliae). Aquatic Mammals 27(2):82-91.

Houser, D. S., L. C. Yeates, and D. E. Crocker. 2011. Cold stress induces an adrenocortical response in bottlenose dolphins (Tursiops truncatus). Journal of Zoo and Wildlife Medicine 42(4):565-571.

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.

Howey, L. A., and coauthors. 2016. Into the deep: the functionality of mesopelagic excursions by an oceanic apex predator. Ecology and Evolution 6(15):5290-5304.

Hubbs, C. L., and A. B. Rechnitzer. 1952. Report on experiments designed to determine effects of underwater explosions on fish life. California Fish and Game 38(3):333-366.

Huggins, J. L., and coauthors. 2015. Increased harbor porpoise mortality in the Pacific Northwest, USA: Understanding when higher levels may be normal. Diseases of Aquatic Organisms 115(2):93-102.

Hughes, T. P. 1984. Population dynamics based on individual size rather than age: A general model with a reef coral example. American Naturalist 123(6):778-795.

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.

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.

Humber, F., B. J. Godley, and A. C. Broderick. 2014. So excellent a fishe: a global overview of legal marine turtle fisheries. Diversity and Distributions 20(5):579-590.

Humphrey, C., M. Weber, C. Lott, T. Cooper, and K. Fabricius. 2008. Effects of suspended sediments, dissolved inorganic nutrients and salinity on fertilisation and embryo development in the coral *Acropora millepora* (Ehrenberg, 1834). Coral reefs 27(4):837-850.

Hurford, W. E., and coauthors. 1996. Splenic contraction, catecholamine release, and blood volume redistribution during diving in the Weddell seal. Journal of Applied Physiology 80(1):298-306.

Huveneers, C., and coauthors. 2013. Effects of an electric field on white sharks: in situ testing of an electric deterrent. PLoS ONE, 8(5), e62730. .

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. 2018. Summary for Policymakers. 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* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland:32pp.

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.

Ivashchenko, Y. V., R. L. Brownell Jr., and P. J. Clapham. 2014. Distribution of Soviet catches of sperm whales *Physeter macrocephalus* in the North Pacific. Endangered Species Research 25(3):249-263.

Ivashchenko, Y. V., P. J. Clapham, and R. L. Brownell Jr. 2013. Soviet catches of whales in the North Pacific: Revised totals. Journal of Cetacean Research and Management 13(1):59–71.

IWC. 2007. Whale population estimates. International Whaling Commission, https://iwc.int/estimate.

IWC. 2016. Report of the Scientific Committee. Journal of Cetacean Research and Management (Supplement) 17.

Jackson, J., and coauthors. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293(5530):629-638.

Jacobsen, J. K., L. Massey, and F. Gulland. 2010. Fatal ingestion of floating net debris by two sperm whales (Physeter macrocephalus). Marine Pollution Bulletin 60:765-767.

Jahoda, M., and coauthors. 2003. Mediterranean Fin Whale's (Balaenoptera physalus) response to small vessels and biopsy sampling assessed through passive tracking and timing of respiration. Marine Mammal Science 19(1):96-110.

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.

James, M. C., S. A. Sherrill-Mix, and R. A. Myers. 2007. Population characteristics and seasonal migrations of leatherback sea turtles at high latitudes. Marine Ecology Progress Series 337:245-254.

Jamieson, A. J., and coauthors. 2019. Microplastics and synthetic particles ingested by deep-sea amphipods in six of the deepest marine ecosystems on Earth. Royal Society of Open Science 6:e180667.

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.

Jefferson, T. A., and B. E. Curry. 1996. Acoustic methods of reducing or eliminating marine mammal-fishery interactions: Do they work? Ocean and Coastal Management 31(1):41-70.

Jefferson, T. A., M. A. Webber, and R. L. Pitman. 2008. Marine Mammals of the World: A Comprehensive Guide to Their Identification. Elsevier, London, United Kingdom.

Jensen, A. S., and G. K. Silber. 2004. Large whale ship strike database. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

Jepson, P. D., and coauthors. 2003. Gas-bubble lesions in stranded cetaceans: Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? Nature 425(6958):575-576.

Jepson, P. D., and coauthors. 2005a. Relationships between polychlorinated biphenyls and health status in harbor porpoises (Phocoena phocoena) stranded in the United Kingdom. Environmental Toxicology and Chemistry 24(1):238-248.

Jepson, P. D., and coauthors. 2005b. Acute and chronic gas bubble lesions in cetaceans stranded in the United Kingdom. Veterinary Pathology 42(3):291-305.

Jessop, T. S. 2001. Modulation of the adrenocortical stress response in marine turtles (Cheloniidae): evidence for a hormonal tactic maximizing maternal reproductive investment Journal of Zoology 254:57-65.

Jessop, T. S., M. Hamann, M. A. Read, and C. J. Limpus. 2000. Evidence for a hormonal tactic maximizing green turtle reproduction in response to a pervasive ecological stressor. General and Comparative Endocrinology 118:407-417.

Jessop, T. S., J. Sumner, V. Lance, and C. Limpus. 2004. Reproduction in shark-attacked sea turtles is supported by stress-reduction mechanisms. Proceedings of the Royal Society Biological Sciences Series B 271:S91-S94.

Jessop, T. S., A. D. Tucker, C. J. Limpus, and J. M. Whittier. 2003. Interactions between ecology, demography, capture stress, and profiles of corticosterone and glucose in a free-living population of Australian freshwater crocodiles. General and Comparative Endocrinology 132(1):161–170.

Jones, T. T., and K. S. V. Houtan. 2014. Sea turtle tagging in the Mariana Islands Range Complex (MIRC) interim report. NOAA, NMFS, PIFSC.

Jones, T. T., and coauthors. 2018. Review of draft response to PRD's request for information to support ESA section 7 consultation on the effects of Hawaii-based longline fisheries on ESA listed species. NMFS Pacific Islands Fisheries Science Center, Honolulu, HI.

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.

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.

Joyce, T. W., and coauthors. 2019. Behavioral responses of satellite tracked Blainville's beaked whales (Mesoplodon densirostris) to mid-frequency active sonar. Marine Mammal Science.

Jurasz, C. M., and V. Jurasz. 1979. Feeding modes of the humpback whale, Megaptera novaeangliae, in southeast Alaska. Scientific Reports of the Whales Research Institute, Tokyo 31:69-83.

Kajiura, S. M., and K. N. Holland. 2002. Electroreception in juvenile scalloped hammerhead and sandbar sharks. Journal of Experimental Biology 205:3609-3621.

Kalmijn, A. J. 2000. Detection and processing of electromagnetic and near-field acoustic signals in elasmobranch fishes. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences 355(1401):1135-1141.

Kamezaki, N., and coauthors. 2003. Loggerhead sea turtles. Pages 210-217 *in* A. B. Bolten, and B. E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Institution, 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.

Kastak, D., and coauthors. 2007. Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (Zalophus californianus). Journal of the Acoustical Society of America 122(5):2916-2924.

Kastak, D., B. L. Southall, R. J. Schusterman, and C. R. Kastak. 2005. Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. Journal of the Acoustical Society of America 118(5):3154-3163.

Kastelein, R. A., I. V. D. Belt, R. Gransier, and T. Johansson. 2015a. Behavioral responses of a harbor porpoise (Phocoena phocoena) to 255- to 245-kHz sonar down-sweeps with and without side bands. Aquatic Mammals 41(4):400-411.

Kastelein, R. A., I. V. D. Belt, L. Helder-Hoek, R. Gransier, and T. Johansson. 2015b. Behavioral responses of a harbor porpoise (Phocoena phocoena) to 25-kHz FM sonar signals. Aquatic Mammals 41(3):311-326.

Kastelein, R. A., R. Gransier, and L. Hoek. 2013a. Comparative temporary threshold shifts in a harbor porpoise and harbor seal, and severe shift in a seal. Journal of the Acoustical Society of America 134(1):13-16.

Kastelein, R. A., R. Gransier, L. Hoek, A. Macleod, and J. M. Terhune. 2012a. Hearing threshold shifts and recovery in harbor seals (Phoca vitulina) after octave-band noise exposure at 4 kHz. Journal of the Acoustical Society of America 132(4):2745-2761.

Kastelein, R. A., R. Gransier, L. Hoek, and J. Olthuis. 2012b. Temporary threshold shifts and recovery in a harbor porpoise (Phocoena phocoena) after octave-band noise at 4 kHz. Journal of the Acoustical Society of America 132:3525-3537.

Kastelein, R. A., R. Gransier, J. Schop, and L. Hoek. 2015c. Effects of exposure to intermittent and continuous 6-7 kHz sonar sweeps on harbor porpoise (Phocoena phocoena) hearing. Journal of the Acoustical Society of America 137(4):1623-1633.

Kastelein, R. A., D. D. Haan, N. Vaughan, C. Staal, and N. M. Schooneman. 2001. The influence of three acoustic alarms on the behaviour of harbour porpoises (Phocoena phocoena) in a floating pen. Marine Environmental Research 52(4):351-371.

Kastelein, R. A., L. Helder-Hoek, and R. Gransier. 2019. Frequency of greatest temporary hearing threshold shift in harbor seals (Phoca vitulina) depends on fatiguing sound level. The Journal of the Acoustical Society of America 145(3):1353.

Kastelein, R. A., and coauthors. 2014a. Hearing thresholds of harbor seals (Phoca vitulina) for playbacks of seal scarer signals, and effects of the signals on behavior. Hydrobiologia.

Kastelein, R. A., L. Hoek, R. Gransier, M. Rambags, and N. Claeys. 2014b. Effect of level, duration, and inter-pulse interval of 1-2kHz sonar signal exposures on harbor porpoise hearing. Journal of the Acoustical Society of America 136(1):412-422.

Kastelein, R. A., J. Huybrechts, J. Covi, and L. Helder-Hoek. 2017. Behavioral Responses of a Harbor Porpoise (Phocoena phocoena) to Sounds from an Acoustic Porpoise Deterrent. Aquatic Mammals 43(3):233-244.

Kastelein, R. A., N. Jennings, W. C. Verboom, D. D. Haan, and N. M. Schooneman. 2006. Differences in the response of a striped dolphin (Stenella coeruleoalba) and a harbour porpoise (Phocoena phocoena) to an acoustic alarm. Marine Environmental Research 61(3):363-378.

Kastelein, R. A., J. Schop, R. Gransier, and L. Hoek. 2014c. Frequency of greatest temporary hearing threshold shift in harbor porpoises (Phocoena phocoena) depends on the noise level. Journal of the Acoustical Society of America 136(3):1410-1418.

Kastelein, R. A., J. Schop, R. Gransier, N. Steen, and N. Jennings. 2014d. Effect of series of 1 to 2 kHz and 6 to 7 kHz up-sweeps and down-sweeps on the behavior of a harbor porpoise (Phocoena phocoena). Aquatic Mammals 40(3):232-242.

Kastelein, R. A., D. van Heerden, R. Gransier, and L. Hoek. 2013b. Behavioral responses of a harbor porpoise (*Phoceoena phocoena*) to playbakcs of broadband pile driving sounds. Marine Environmental Research 92:206–214.

Kastelein, R. A., W. C. Verboom, M. Muijsers, N. V. Jennings, and S. Van Der Heul. 2005. The influence of acoustic emissions for underwater data transmission on the behavior of harbour poroises (Phocoena phocoena) in a floating pen. Marine Enviornmental Research 59:287-307.

Keevin, T. M., and G. L. Hempen. 1997. The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts. U.S. Army Corps of Engineers, St. Louis, MO.

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. .

Kenyon, J. C. 1995. Hybridization and polyploidy in the coral genus Acropora.

Kenyon, J. C. 2008. Acropora (Anthozoa: Scleractinia) Reproductive Synchrony and Spawning Phenology in the Northern Line Islands, Central Pacific, as Inferred from Size Classes of Developing Oocytes1. Pacific Science 62(4):569-579.

Ketten, D. R. 1992. The cetacean ear: Form, frequency, and evolution. Pages 53-75 *in* J. A. Thomas, R. A. Kastelein, and A. Y. Supin, 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 Audiometroc and Anatomical Data and its Implications for Underwater Acoustic Impacts. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-256.

Ketten, D. R. 2000. Cetacean ears. Pages 43-108 *in* W. W. L. A. A. N. P. R. R. Fay, editor. Hearing by Whales and Dolphins. Springer-Verlag, New York.

Ketten, D. R., and S. M. Bartol. 2006. Functional measures of sea turtle hearing. Office of Naval Research, Arlington, VA.

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.

Kindt-Larsen, L., C. W. Berg, S. Northridge, and F. Larsen. 2018. Harbor porpoise (Phocoena phocoena) reactions to pingers. Marine Mammal Science 35(2):552-573.

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.

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. 2007. Underwater noise from skiffs to ships. Pages 172-175 *in* Fourth Glacier Bay Science Symposium.

Kirschvink, J. L. 1990. Geomagnetic sensitivity in cetaceans: An update with live stranding records in the Unites States. Pages 639-649 *in* R. A. J. A. K. Thomas, editor. Sensory Abilities of Cetaceans: Laboratory and Field Evidence.

Kirschvink, J. L., A. E. Dizon, and J. A. Westphal. 1986. Evidence from strandings for geomagnetic sensitivity in cetaceans. Journal of Experimental Biology, 120, 1–24. .

Kittinger, J. N., K. S. V. Houtan, L. E. McClenachan, and A. L. Lawrence. 2013. Using historical data to assess the biogeography of population recovery. Ecography 36(8):868-872.

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 A. A. Myrberg. 1979. Acoustic stimuli underlying withdrawal from a sound source by adult lemon sharks, Negaprion brevirostris (Poey). Bulletin of Marine Science 29:447-458.

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.

Klinck, H., and coauthors. 2016. Cetacean Studies on the Kona Coast in March 2010: Passive Acoustic Monitoring of Marine Mammals Using Gliders–Results from an Engineering Test. Final Report. HDR Inc., Honolulu, HI.

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., C. W. Clark, and S. Kraus. 1991. Sounds recorded in the presence of sei whale, *Balaenoptera borealis*. Acoustical Society of America.

Knowlton, A. R., P. K. Hamilton, M. 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.

Kobayashi, D. R., and coauthors. 2008. Pelagic habitat characteriation of loggerhead sea turtles, Caretta caretta, in the North Pacific Ocean (1997-2006): insights from satellite tag tracking and remotely sensed data. Journal of Marine Biology and Ecology 356:96-114.

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.

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. .

Kolinski, S. P., and coauthors. 2006. Nearshore distribution and an abundance estimate for green sea turtles, *Chelonia mydas*, at Rota Island, commonwealth of the Northern Mariana Islands. Pacific Science 60(4):509-522.

Kolinski, S. P., D. M. Parker, L. I. Ilo, and J. K. Ruak. 2001. An assessment of the sea turtles and their marine and terrestrial habitats at Saipan, Commonwealth of the Northern Mariana Islands. Micronesica 34(1):55-72.

Kooyman, G. L., D. H. Kerem, W. B. Campbell, and J. J. Wright. 1973. Pulmonary gas exchange in freely diving weddell seals Leptonychotes weddelli. Respiration Physiology 17(3):283-290.

Kooyman, G. L., and coauthors. 1972. Blood nitrogen tensions of seals during simulated deep dives. American Journal of Physiology 223(5):1016-1020.

Kooyman, G. L., and E. E. Sinnett. 1982. Pulmonary shunts in harbor seals and sea lions during simulated dives to depth. Physiological Zoology 55(1):105-111.

Koski, W. R., and coauthors. 2015. Evaluation of UAS for photographic re-identification of bowhead whales, Balaena mysticetus. Journal of Unmanned Vehicle Systems 3(1):22-29.

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.

Kragh Boye, T., M. Simon, and P. T. Madsen. 2010. Habitat use of humpback whales in Godthaabsfjord, West Greenland, with implications for commercial exploitation. Journal of the Marine Biological Association of the United Kingdom 90(8):1529-1538.

Kruse, S. 1991. The interactions between killer whales and boats in Johnstone Strait, B.C. K. Pryor, and K. Norris, editors. Dolphin Societies: Discoveries and Puzzles. University of California Press.

Kryter, K. D., W. D. Ward, J. D. Miller, and D. H. Eldredge. 1965. Hazardous exposure to intermittent and steady-state noise. Journal of the Acoustical Society of America 39(3):451-464.

Kufeld, W. G., and R. M. Bousman. 2005. UH-60A airloads catalog. National Aeronautics and Space Administration.

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.

Kuningas, S., P. H. Kvadsheim, F. P. A. Lam, and P. J. O. Miller. 2013. Killer whale presence in relation to naval sonar activity and prey abundance in northern Norway. ICES Journal of Marine Science 70(7):1287-1293.

Kvadsheim, P. 2012. Estimated tissue and blood N2 levels and risk of decompression sickness in deep-, intermediate-, and shallow-diving toothed whales during exposure to naval sonar. Frontiers in Physiology 3.

Kvadsheim, P. H., and coauthors. 2017. Avoidance responses of minke whales to 1-4kHz naval sonar. Mar Pollut Bull.

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 Forskningsinstitutt.

Kvadsheim, P. H., E. M. Sevaldsen, L. P. Folkow, and A. S. Blix. 2010. Behavioural and physiological responses of hooded seals (Cystophora cristata) to 1 to 7 kHz sonar signals. Aquatic Mammals 36(3):239-247.

Kyhn, L. A., and coauthors. 2015. Pingers cause temporary habitat displacement in the harbour porpoise Phocoena phocoena. Marine Ecology Progress Series 526:253-265.

Ladich, F., and R. R. Fay. 2013. Auditory evoked potential audiometry in fish. 23(3):317-364.

Lagerquist, B. A., K. M. Stafford, and B. R. Mate. 2000. Dive characteristics of satellite-monitored blue whales (*Balaenoptera musculus*) off the Central California coast. Marine Mammal Science 16(2):375-391.

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., 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., N. Esteban, J. Berkel, and G. C. Hays. 2016. Sand temperatures for nesting sea turtles in the Caribbean: Implications for hatchling sex ratios in the face of climate change. Journal of Experimental Marine Biology and Ecology 474:92–99.

Lammers, M. O., and coauthors. 2017. Acoustic monitoring of coastal dolphins and their response to naval mine neutralization exercises. Royal Society Open Science 4(12):e170558.

Lance, V. A., R. M. Elsey, G. Butterstein, and P. L. Trosclair Iii. 2004. Rapid suppression of testosterone secretion after capture in male American alligators (*Alligator mississippiensis*). General and Comparative Endocrinology 135(2):217–222.

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.

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.

Lasker, H. R. 1980. Sediment rejection by reef corals: The roles of behavior and morphology in *Montastrea cavernosa* (Linnaeus). Journal of Experimental Marine Biology and Ecology 47(1):77-87.

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.

Law, K. L., and coauthors. 2010. Plastic accumulation in the North Atlantic subtropical gyre. Science 329(5996):1185-1188.

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.

Leatherwood, S., D. K. Caldwell, and H. E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: A guide to their identification. NOAA Technical Report NMFS CIRCULAR No. 396. 176p.

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.

Lenhardt, M. L., S. E. Moein, J. A. Musick, and D. E. Barnard. 1994. Evaluation of the Response of Loggerhead Sea Turtles (Caretta caretta) to a Fixed Sound Source. Draft Final Report Submitted to the U.S. Army Corps of Engineers, Waterways Experiment Station:13.

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.

Leroy, E. C., J. Y. Royer, J. Bonnel, and F. Samaran. 2018. Long-Term and Seasonal Changes of Large Whale Call Frequency in the Southern Indian Ocean. Journal of Geophysical Research-Oceans 123(11):8568-8580.

Lesage, V., C. Barrette, M. C. S. Kingsley, and B. Sjare. 1999. The effect of vessel noise on the vocal behavior of Belugas in the St. Lawrence River estuary, Canada. Marine Mammal Science 15(1):65-84.

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.

Lewis, L. A., and coauthors. 2018. Context-dependent variability in blue whale acoustic behaviour. Royal Society Open Science 5(8).

Lewison, R. L., L. B. Crowder, A. J. Read, and S. A. Freeman. 2004. Understanding impacts of fisheries bycatch on marine megafauna. Trends in ecology & evolution 19(11):598-604.

LGL, L. 2008. Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G. Langseth in Southeast Asia, March–July 2009 Palisades, NY: Lamont- Doherty Earth Observatory.

Liboff, A. 2016. Is the geomagnetic map imprinted in pre-emergent egg? Electromagnetic biology and medicine 35(2):167-169.

Ligon, A. D., M. H. Deakos, and A. D. U. 2011. Small-boat cetacean surveys off Guam and Saipan, Mariana Islands, February - March 2010. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Island Fisheries Science Center.

Lima, S. L. 1998. Stress and decision making under the risk of predation. Advances in the Study of Behavior 27:215-290.

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 Otalaryngology 12(605-616).

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.

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.

Lohmann, K. J., B. E. Witherington, C. M. F. Lohmann, and M. Salmon. 1997. Orientation, navigation, and natal beach homing in sea turtles. P. L. Lutz, and J. A. Musick, editors. The Biology of Sea Turtles, Boca Raton, FL: CRC Press.

Lopez, P., and J. Martin. 2001. Chemosensory predator recognition induces specific defensive behaviours in a fossorial amphisbaenian. Animal Behaviour 62:259-264.

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.

Loya, Y., and coauthors. 2001. Coral bleaching: The winners and the losers. Ecology letters 4(2):122-131.

Luksenburg, J. A., and E. C. Parsons. 2009. The effects of aircraft on cetaceans: Implications for aerial whalewatching.

Lundquist, D., N. J. Gemmell, and B. Wursig. 2012. Behavioural responses of dusky dolphin groups (*Lagenorhynchus obscurus*) to tour vessels off Kaikoura, New Zealand. PloS one 7(7):e41969.

Lusseau, D. 2003. Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts. Conservation Biology 17(6):1785-1793.

Lusseau, D. 2004. The hidden cost of tourism: Detecting long-term effects of tourism using behavioral information. Ecology and Society 9(1):2.

Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22(4):802-818.

Lyamin, O. I., S. M. Korneva, V. V. Rozhnov, and L. M. Mukhametov. 2011. Cardiorespiratory changes in beluga in response to acoustic noise. Doklady Biological Sciences 440(1):275-278.

Lybolt, M. 2015. Listed Coral Sighting (Guam). Technical Memorandum from M. Lybolt, Marine Ecologist, Tetra Tech, Inc., Stuart, FL to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. May 4.

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.

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.

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.

Magnusdottir, E. E., and R. Lim. 2019. Subarctic singers: Humpback whale (Megaptera novaeangliae) song structure and progression from an Icelandic feeding ground during winter. PLoS One 14(1):e0210057.

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 Artic 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.

Mancl, K. 1996. Wastewater Treatment Principles and Regulations. Ohio State University College of Food, Agricultural and Environmental Sciences.

Mantua, N. J., and S. R. Hare. 2002. The Pacific decadal oscillation. Journal of Oceanography 58(1):35-44.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6):1069-1079.

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. .

Marcoux, M., H. Whitehead, and L. Rendell. 2006. Coda vocalizations recorded in breeding areas are almost entirely produced by mature female sperm whales (*Physeter macrocephalus*). Canadian Journal of Zoology 84(4):609-614.

Márquez, M. R. 1990. Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date.

Marsh, H. E. 1989. Mass stranding of dugongs by a tropical cyclone in northern Australia. Marine Mammal Science 5(1):78–84.

Marszalek, D. S. 1981. Impact of dredging on a subtropical reef community, Southeast Florida, U.S.A. Pages 147-153 *in* Fourth International Coral Reef Symposium, Manila.

Martin, C., and coauthors. 2019a. FY18 Annual Report on Pacific Missile Range Facility Marine Mammal Monitoring. U.S. Navy, San Diego, California.

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., A. Gaos, and T. Jones. 2019b. Sea turtle tagging in the Mariana Islands Training and Testing (MITT) study area.

Martin, S. L., T. T. Jones, and A. R. Gaos. 2018. Sea turtle tagging in the Mariana Islands Training and Testing (MITT) study area, 31 January 2018. Marine Turtle Biology and Assessment Program (MTBAP), Protected Species Division (PSD), Pacific Islands Fisheries Science Center (PIFSC), NOAA Fisheries.

Martin, S. L., and coauthors. 2020. Assessing the population level impacts of North Pacific Loggerhead and western Pacific Leatherback interactions in the Hawaii-based shallow set longline fishery.

Martin, S. L., and coauthors. 2016. Five decades of marine megafauna surveys of Micronesia. Frontiers in Marine Science 2(116).

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.

Masaki, Y. 1976. Biological studies on the North Pacific sei whale. Bulletin of the Far Seas Fisheries Research Laboratory 14:1-104 +1pl.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. Report of the International Whaling Commission Special Issue 1:71-79.

Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. Natural history of Oregon coast mammals. U.S. Department of Agriculture, Forest Service, PNW-133, Portland, OR.

Mateo, J. M. 2007. Ecological and hormonal correlates of antipredator behavior in adult Belding's ground squirrels (*Spermophilus beldingi*). Behavioral Ecology and Sociobiology 62(1):37-49.

Mather, J. 2004. Cephalopod skin displays: From concealment to communication. D. K. O. U. Griebel, editor. The Evolution of Communication Systems: A Comparitive Approach.

The Vienna Series in Theoretical Biology and the Massachusettes Institute of Technology, Cambridge, Massachusetts.

Matsuzawa, Y. 2011. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Contract Report to the Western Pacific Regional Fishery Management Council.

Matsuzawa, Y., and coauthors. 2016. Fine-scale genetic population structure of loggerhead turtles in the Northwest Pacific. Endangered Species Research 30:83-93.

May-Collado, L. J., and D. Wartzok. 2008. A comparison of bottlenose dolphin whistles in the Atlantic Ocean: Factors promoting whistle variation. Journal of Mammalogy 89(5):1229-1240.

Maybaum, H. L. 1990. Effects of a 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae*, in Hawaiian waters. EOS 71:92.

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.

McCauley, R. D., and coauthors. 2000a. Marine seismic surveys - a study of environmental implications. Appea Journal 40:692-708.

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.

Mcdonald, B. I., and P. J. Ponganis. 2012. Lung collapse in the diving sea lion: Hold the nitrogen and save the oxygen. Biology Letters 8(6):1047-1049.

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. Mesnick. 2009. Worldwide decline in tonal frequencies of blue whale songs. Endangered Species Research 9(1):13-21.

McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. The Journal of Acoustical Society of America 98(2):712–721.

McDonald, M. A., and coauthors. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical Society of America 118(6):3941-3945.

McDonald, M. A., S. L. Mesnick, and J. A. Hildebrand. 2006. Biogeographic characterisation of blue whale song worldwide: Using song to identify populations. Journal of Cetacean Research and Management 8(1):55-65.

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.

McMahon, C. R., and H. R. Burton. 2005. Climate change and seal survival: Evidence for environmentally mediated changes in elephant seal, Mirounga leonina, pup survival. Proceedings of the Royal Society of London Series B Biological Sciences 272(1566):923-928.

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.

McManus, J. W. 1997. Tropical marine fisheries and the future of coral reefs: a brief review with emphasis on Southeast Asia. 16 (S121-S127).

McSweeney, D. J., K. C. Chu, W. F. Dolphin, and L. N. Guinee. 1989. North Pacific humpback whale songs - a comparison of southeast Alaskan feeding ground songs with Hawaiian wintering ground songs. Marine Mammal Science 5(2):139-148.

Mead, K. S., and M. W. Denny. 1995. The effects of hydrodynamic shear stress on fertilization and early development of the purple sea urchin *Strongylocentrus purpatus*. Biological Bulletin 188:46-56.

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.

Mercado, E., Iii. 2018. The Sonar Model for Humpback Whale Song Revised. Frontiers in Psychology 9:1156.

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.

Miksis, J. L., and coauthors. 2001. Cardiac responses to acoustic playback experiments in the captive bottlenose dolphin (Tursiops truncatus). Journal of Comparative Psychology 115(3):227-232.

Miller, J. D., K. A. Dobbs, C. J. Limpus, N. Mattocks, and A. M. Landry Jr. 1998. Long-distance migrations by the hawksbill turtle, *Eretmochelys imbricata*, from north-eastern Australia. Wildlife Research 25(1):89-95.

Miller, M. H., and coauthors. 2014a. Status review report: scalloped hammerhead shark (*Sphyrna lewini*). Final Report to NMFS, Office of Protected Resources.

Miller, M. H., and C. Klimovich. 2017. Endangered Species Act Status Review Report: Giant Manta Ray (*Manta birostris*) and Reef Manta Ray (*Manta alfredi*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

Miller, P., and coauthors. 2011. The 3S experiments: Studying the behavioural effects of naval sonar on killer whales (Orcinus orca), sperm whales (Physeter macrocephalus), and long-finned pilot whales (Globicephala melas) in Norwegian waters. Scottish Oceans Institute.

Miller, P. J. O., and coauthors. 2014b. Dose-response relationships for the onset of avoidance of sonar by free-ranging killer whales. Journal of the Acoustical Society of America 135(2):975-993.

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, P. J. O., and coauthors. 2015. First indications that northern bottlenose whales are sensitive to behavioural disturbance from anthropogenic noise. Royal Society Open Science 2:140484.

Milsom, W. K. 1975. Development of buoyancy control in juvenile Atlantic loggerhead turtles, Caretta c. caretta. Copeia 1975(4):758-762.

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.

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.

Miyashita, T., and coauthors. 1996. Winter distribution of cetaceans in the western North Pacific inferred from sighting cruises 1993-1995. Report of the International Whaling Commission 46:437-441.

MMC. 2007. Marine mammals and noise: A sound approach to research and management. Marine Mammal Commission.

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.

Mobley, J. R., M. A. Smultea, C. E. Bacon, and A. Frankel. 2012. Preliminary Report: Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex--Summary of Focal Follow Analysis for 2008–2012 SCC Events: Preliminary Report. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, Hawaii 96860-3134, under Contract # N62470-10-D-3011, 11 June 2013, issued to HDR Inc., San Diego, California 92123. 11 June 2013.

Moein Bartol, S., and D. R. Ketten. 2006. Turtle and tuna hearing. Pp.98-103 In: Swimmer, Y. and R. Brill (Eds), Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-7.

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.

Monnahan, C. C., T. A. Branch, and A. E. Punt. 2015. Do ship strikes threaten the recovery of endangered eastern North Pacific blue whales? Marine Mammal Science 31(1):279-297.

Monzón-Argüello, C., C. Rico, A. Marco, P. López, and L. F. López-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.

Moon, H.-B., and coauthors. 2010. Chlorinated and brominated contaminants including PCBs and PBDEs in minke whales and common dolphins from Korean coastal waters. Journal of Hazardous Materials 179(1-3):735-741.

Mooney, T. A., P. E. Nachtigall, M. Breese, S. Vlachos, and W. W. L. Au. 2009a. Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): The effects of noise level and duration. Journal of the Acoustical Society of America 125(3):1816-1826.

Mooney, T. A., P. E. Nachtigall, and S. Vlachos. 2009b. Sonar-induced temporary hearing loss in dolphins. Biology Letters 5(4):565-567.

Moore, M. J., and coauthors. 2009. Gas bubbles in seals, dolphins, and porpoises entangled and drowned at depth in gillnets. Veterinary Pathology 46(3):536-547.

Moore, M. J., and G. A. Early. 2004. Cumulative sperm whale bone damage and the bends. Science 306(5705):2215.

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.

Morgan, R. P., R. E. Ulanowicz, J. J. Rasin, L. A. Noe, and B. Gray. 2011. Effects of shear on eggs and larvae of striped bass, *Morone saxatalis*, and white perch, *M. americana*. Transactions of the American Fisheries Society 105(1):149-154.

Mrosovsky, N. 1994. Sex ratios of sea turtles. The Journal of Experimental Zoology 270:16-27.

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

Mulsow, J., C. E. Schlundt, L. Brandt, and J. J. Finneran. 2015. Equal latency contours for bottlenose dolphins (Tursiops truncatus) and California sea lions (Zalophus californianus). The Journal of the Acoustical Society of America 138(5):2678-2691.

Mundy, P. R. 2005. The Gulf of Alaska: Biology and Oceanography. Alaska Sea Grant College Program, University of Alaska, Fairbanks.

Mundy, P. R., and R. T. Cooney. 2005. Physical and biological background. Pages 15-23 *in* P. R. Mundy, editor. The Gulf of Alaska: Biology and oceanography. Alaska Sea Grant College Program, University of Alaska, Fairbanks, Alaska.

Munger, L., and M. Lammers. 2020. Humpback whale song occurrence in Ecological Acoustic Recorder (EAR) data from Pagan and Maug (Northern Mariana Islands), 2009-2010. DoN, U.S. Pacific Fleet, Honolulu, Hawaii.

Munger, L. M., M. O. Lammers, and W. Au. 2014. Passive Acoustic Monitoring for Cetaceans within the Marianas Islands Range Complex (MIRC). Preliminary Report. Prepared for U.S. Pacific Fleet. Submitted to Naval Facilities Engineering Command (NAVFAC) Pacific, Honolulu, Hawaii under Contract No. N62470-10-D-3011, Task Orders KB14 and KB 17, issued to HDR Inc., Honolulu, Hawaii. Prepared by Oceanwide Science Institute, Honolulu, Hawaii and Hawaii Institute of Marine Biology, Kaneohe, Hawaii. 10 February 2014.

Munger, L. M., M. O. Lammers, J. N. Oswald, T. M. Yack, and W. Au. 2015. Passive Acoustic Monitoring of Cetaceans within the Mariana Islands Range Complex (MIRC) Using Ecological Acoustic Recorders (EARs). Final Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. Submitted to Naval Facilities Engineering Command Pacific, EV2 Environmental Planning, Pearl Harbor, HI under Contract No. N62470-10-D-3011 Task Orders KB14 and KB22 issued to HDR Inc., Honolulu, HI. 29 September.

Musick, J. A., and C. J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. Pages 137-163 *in* P. Lutz, and J. A. Musick, editors. The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Muto, M. M., and coauthors. 2017. Alaska Marine Mammal Stock Assessments, 2016. Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, NMFS-AFSC-355, Seattle, Washington.

Muto, M. M., and coauthors. 2019. Alaska marine mammal stock assessments, 2018. U.S. Dept. of Commerce.

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. 1975a. 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. 1975b. Rapid Withdrawal from a Sound Source by Sharks under Open-Ocean and Captive Conditions. Rosenstiel School of Marine and Atmospheric Science, TR75-5 University of Miami, Tech. Rept. to Office of Nav. Res., Contract No. N00014-67-A-0201-0008.

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 the Acoustical Society of America 64:1289-1297.

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., and A. Y. Supin. 2014. Conditioned hearing sensitivity reduction in a bottlenose dolphin (Tursiops truncatus). Journal of Experimental Biology 217(16):2806-2813.

Nachtigall, P. E., A. Y. Supin, J. A. Estaban, and A. F. Pacini. 2016. Learning and extinction of conditioned hearing sensation change in the beluga whale (Delphinapterus leucas). Journal of Comparative Physiology. A, Neuroethology, Sensory, Neural, and Behavioral Physiology 202(2):105-113.

Nachtigall, P. E., A. Y. Supin, A. F. Pacini, and R. A. Kastelein. 2017. Four Odontocete Species Change Hearing Levels When Warned of Impending Loud Sound. Integrative Zoology 13:160-165.

Nachtigall, P. E., A. Y. Supin, J. L. Pawloski, and W. W. L. Au. 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (Tursiops truncatus) measured using evoked auditory potentials. Marine Mammal Science 20(4):672-687.

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.

Nalesso, E., and coauthors. 2019. Movements of scalloped hammerhead sharks (Sphyrna lewini) at Cocos Island, Costa Rica and between oceanic islands in the Eastern Tropical Pacific. PloS one 14(3):e0213741.

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.

Navy. 2003. Report on the Results of the Inquiry into Allegations of Marine Mammal Impacts Surrounding the Use of Active Sonar by USS SHOUP (DDG 86) in the Haro Strait on or about 5 May 2003.

Navy. 2011a. Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2011 Annual Report. U.S. Navy Pacific Fleet.

Navy. 2011b. Marine Species Monitoring, Information on Sightings Recorded by U.S. Navy MMOs on Vessels during Sonar Test Events in the Naval Surface Warfare Center Panama City Division (NSWC PCD). Submitted to National Marine Fisheries Service, Office of Protected Resources. Department of the Navy, United States Fleet Forces Command, Norfolk, VA.

Navy. 2013a. Comprehensive Exercise and Marine Species Monitoring Report For the U.S. Navy's Atlantic Fleet Active Sonar Training (AFAST) and Virginia Capes, Cherry Point, Jacksonville, and Gulf of Mexico Range Complexes 2009–2012. Department of the Navy, United States Fleet Forces Command, Norfolk, Virginia.

Navy. 2013b. Hawaii-Southern California Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement.

Navy. 2013c. Water Range Sustainability Environmental Program Assessment, Potomac River Test Range Complex. Dahlgren, VA.

Navy. 2014a. Marine Species Monitoring Report for the U.S. Navy's Atlantic Fleet Active Sonar Training (AFAST) and Virginia Capes, Cherry Point, Jacksonville, and Gulf of Mexico Range Complexes - Annual Report 2013. Department of the Navy, United States Fleet Forces Command, Norfolk, VA.

Navy. 2014b. Unclassified Annual Range Complex Exercise Report, 2 August 2012 to 25 November 2013, for the U.S. Navy's Atlantic Fleet Active Sonar Training (AFAST) Study Area. Prepared for and submitted to National Marine Fisheries Service, Office of Protected Resources. Prepared by the U.S. Department of the Navy in accordance with the Letter of Authorization under the MMPA and ITS authorization under the ESA dated 1 February 2012.

Navy. 2015a. Memorandum: Estimation of coral impacts due to use of munitions at FDM. Environmental Readiness Division (N465), U.S. Pacific Fleet.

Navy. 2015b. Unclassified 2014 Annual Atlantic Fleet Training and Testing (AFTT) Exercise and Testing Report 14 November 2013 to 13 November 2014. Prepared for and submitted to National Marine Fisheries Service, Office of Protected Resources. Prepared by the U.S. Department of the Navy in accordance with the Letter of Authorization under the MMPA and ITS authorization under the ESA dated 14 November 2013.

Navy. 2017a. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). SSC Pacific.

Navy. 2017b. Draft Environmental Impact Statement/Overseas Environmental Impact Statement Hawaii-Southern California Training and Testing. U.S. Department of the Navy.

Navy. 2017c. Marine Mammal Strandings Associated with U.S. Navy Sonar Activities. U.S. Navy Marine Mammal Program. SPAWAR Systems Center Pacific.

Navy. 2018a. Final Environmental Impact Statement/Overseas Environmental Impact Statement for Atlantic Fleet Training and Testing.

Navy. 2018b. Hawaii-Southern California Training and Testing Biological Assessment to Support Endangered Species Act Section 7 Consultation with the National Marine Fisheries Service. United States Department of the Navy; Commander, United States Pacific Fleet; Commander, Naval Sea Systems Command.

Navy. 2018c. Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement.

Navy. 2018d. Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing. Technical report prepared by

Space and Naval Warfare Systems Center Pacific, San Diego and Naval Undersea Warfare Center, Newport.

Navy. 2018e. U.S. Navy Marine Species Density Database Phase III for the Mariana Islands Training and Testing Study Area, Pearl Harbor, HI.

Navy. 2019a. Correction to Navy MITT Biological Evaluation of July 2019: Replacement Table 4-2 on Page 4-14.

Navy. 2019b. Email from C. Johnson RE_MITT - statement regarding activities in Sasa Bay, Guam 10_1_2019. Environmental Readiness Division (N465), Southwest Detachment, US Pacific Fleet.

Navy. 2019c. Email from C. Johnson RE_MITT -NAEMO modeled exposures before mitigation_avoidance factors applied 11_19_2019.

Navy. 2019d. Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement for Mariana Islands Training and Testing. United States Department of the Navy.

Navy. 2019e. Mariana Islands Training and Testing Biological Assessment to Support Endangered Species Act Section 7 Consultation with the National Marine Fisheries Service: Final. United States Department of the Navy; Commander, United States Pacific Fleet; Commander, Naval Sea Systems Command.

Navy. 2020a. Additional Navy information for the Chalan Konoa Reef and Marpi Reef Geographic Mitigation Area in the Mariana Islands Training and Testing Area. Department of Navy Memorandum. U.S. Pacific Fleet, Environmental Readiness Division N465.

Navy. 2020b. Navy Chalan Konoa and Marpi Reef Geographic Mitigation Area Revision and Justification. U.S. Pacific Fleet, Environmental Readiness Division N465.

Navy. 2020c. Navy Email to NMFS with Subject: MITT Humpback Whale PTS. From C. Johnson, Navy to R. Salz, NMFS.

Navy. 2020d. Navy Email to NMFS with Subject: Requesting information on mitigation effectiveness factors. From C. Johnson, Navy to R. Salz, NMFS.

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.

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.

New, L. F., and coauthors. 2013a. Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. Functional Ecology 27(2):314-322.

New, L. F., D. J. Moretti, S. K. Hooker, D. P. Costa, and S. E. Simmons. 2013b. Using energetic models to investigate the survival and reproduction of beaked whales (family Ziphiidae). PloS one 8(7):e68725.

Nichols, T., T. Anderson, and A. Sirovic. 2015. Intermittent noise induces physiological stress in a coastal marine fish. PLoS ONE, 10(9), e0139157. .

Nichols, W. J., A. Resendiz, J. A. Seminoff, and B. Resendiz. 2000. Transpacific migration of a loggerhead turtle monitored by satellite telemetry. Bulletin of Marine Science 67(3):937-947.

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.

Nishizawa, H., and coauthors. 2014. Genetic composition of loggerhead turtle feeding aggregations: migration patterns in the North Pacific. Endangered Species Research 24(1):85-93.

NMFS. 1991. Final recovery plan for the humpback whale (*Megaptera novaeangliae*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 1998. Draft recovery plan for the blue whale (*Balaenoptera musculus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2005. Assessment of Acoustic Exposures on Marine Mammals in Conjunction with USS Shoup Active Sonar Transmissions in the Eastern Strait of Juan de Fuca and Haro Strait, Washington, 5 May 2003. National Marine Fisheries Service, Office of Protected Resources.

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. 2011a. Fin whale (Balaenoptera physalus) 5-Year Review: Evaluation and Summary. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2011b. 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. 2012. Sei whale (*Balaenoptera borealis*) 5-year review: Summary and evaluation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

NMFS. 2015a. Endangered and Threatened Species; Determination on the Designation of Critical Habitat for Three Scalloped Hammerhead Shark Distinct Population Segments.

NMFS. 2015b. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report: U.S. Military Mariana Islands Training and Testing Activities and The National Marine Fisheries Services' 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 Mariana Islands Training and Testing activities from August 2015 through August 2020. NOAA/NMFS, Silver Spring, MD.

NMFS. 2015c. Sperm whale (*Physeter macrocephalus*) 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources.

NMFS. 2016. Interim Guidance on the Endangered Species Act Term "Harass." December 2016. Protected Resources Management. National Marine Fisheries Service Procedural Instruction 02-110-10. .

NMFS. 2017a. Biological and Conference Opinion on the Proposed Implementation of a Program for the Issuance of Permits for Research and Enhancement Activities on Threatened and Endangered Sea Turtles Pursuant to Section 10(a) of the Endangered Species Act. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, FPR-2017-9230, Silver Spring, Maryland.

NMFS. 2017b. Biological and Conference Opinion on United States Navy's Surveillance Towed Array Sensor System Low Frequency Active Sonar Routine Training, Testing, and Military Operations from August 2017 through August 2022. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, FPR-2016-9181, Silver Spring, Maryland.

NMFS. 2017c. Biological Opinion on (1) U.S. Military Mariana Islands Training and Testing Activities; 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 Mariana Islands Training and Testing activities from August 2015 through August 2020. Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service.

NMFS. 2018a. 2018 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. U.S. Dept. of Commerce, NOAA.

NMFS. 2018b. Biological Opinion on U.S. Navy Hawaii-Southern California 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 Hawaii-Southern California Training and Testing. NOAA/NMFS/Office of Protected Resources, Silver Spring, MD.

NMFS. 2018c. Draft Recovery Plan for the Blue Whale (*Balaenoptera musculus*) - Revision. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2019a. ESA Section 7(A)(2) Biological Opinion: Continued Authorization of the Hawaii Pelagic Shallow-Set Longline Fishery. NMFS, Pacific Islands Region, Protected Resources Division.

NMFS. 2019b. Fin Whale (*Balaenoptera physalus*) 5-Year Review: Summary and Evaluation. NMFS, Office of Protected Resources, Silver Spring, MD.

NMFS. 2020a. Endangered Species Act Section 7 Biological Opinion on the Federally Regulated Oil and Gas Program Activities in the Gulf of Mexico. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

NMFS, and USFWS. 1991. Recovery plan for U.S. population of Atlantic green turtle *Chelonia mydas*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Washington, D.C.

NMFS, and USFWS. 1992. Recovery plan for leatherback turtles (*Dermochelys coriacea*) in the U.S. Caribben, 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. 1998a. 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.

NMFS, and USFWS. 1998b. Recovery plan for U.S. Pacific populations of the green turtle (*Chelonia mydas*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 1998c. 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. 2007a. 5-year review: Summary and evaluation, green sea turtle (*Chelonia mydas*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS, and USFWS. 2007b. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: Summary and evaluation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2007c. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2007d. Loggerhead sea turtle (*Caretta caretta*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2013a. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: Summary and evaluation National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2013b. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review: Summary and evaluation. National Oceanic and Atmospheric Administration National Marine Fisheries Service, Office of Protected Resources and U.S. Fish and Wildlife Service, Southeast Region, Jacksonvill Ecological Services Office, Jacksonville, Florida.

NMFS, and USFWS. 2015. Kemp's ridley sea turtle (*Lepidochelys kempii*) 5-year review: Summary and evaluation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS, and USFWS. 2020b. Loggerhead Sea Turtle (*Caretta caretta*) North Pacific Ocean DPS 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland and U.S. Fish and Wildlife Service

Southeast Region, North Florida Ecological Services Office, Jacksonville, Florida.

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. 2014c. Southern Resident Killer Whales: 10 Years of Research & Conservation.

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. 2017. Coral Bleaching and Disease. Pacific Islands Fisheries Science Center.

NOAA. 2018. 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0).

Norem, A. D. 2005. Injury assessment of sea turtles utilizing the neritic zone of the southeastern United States. University of Florida, Gainesville.

Noren, D. P., A. H. Johnson, D. Rehder, and A. Larson. 2009. Close approaches by vessels elicit surface active behaviors by southern resident killer whales. Endangered Species Research 8(3):179-192.

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.

Norris, T., and coauthors. 2012a. Acoustic ecology and behavior of minke whales in the Hawaiian and Marianas Islands: Localization, abundance estimation, and characterization of minke whale boings. Pages 5 *in* A. N. Popper, and A. Hawkings, editors. The Effects of Noise on Aquatic Life. Springer Science.

Norris, T. F., J. N. Oswald, T. M. Yack, and E. L. Ferguson. 2012b. An Analysis of Marine Acoustic Recording Unit (MARU) Data Collected off Jacksonville, Florida in Fall 2009 and Winter 2009–2010. Final Report. Submitted to Naval Facilities Engineering Command (NAVFAC) Atlantic, Norfolk, Virginia, under Contract No. N62470-10-D-3011, Task Order 021, issued to HDR Inc., Norfolk, Virginia. Prepared by Bio-Waves Inc., Encinitas, California. 21 November 2012. Revised January 2014.

Northridge, S. 2008. Fishing industry, effects of. Pages 443-447 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, CA.

Notarbartolo-di-Sciara, G., and E. V. Hillyer. 1989. Mobulid rays off eastern Venezuela (Chondrichthyes, Mobulidae). Copeia:607-614.

Nowacek, D. P., F. Christiansen, L. Bejder, J. Goldbogen, and A. Friedlaender. 2016. Studying cetacean behaviour: new technological approaches and conservation applications. Animal Behaviour, 1–10. .

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.

Nowacek, S. M., R. S. Wells, and A. R. Solow. 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 17(4):673-688.

NRC. 2005. Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects. National Academy of Sciences, Washington, D. C.

NRC. 2006. Dynamic changes in marine ecosystems fishing, food webs, and future options. National Research Council of the National Academies.

O'connell, C. P., D. C. Abel, P. H. Rice, E. M. Stroud, and N. C. Simuro. 2010. Responses of the southern stingray (Dasyatis americana) and the nurse shark (Ginglymostoma cirratum) to permanent magnets. Marine and Freshwater Behaviour and Physiology 43(1):63-73.

O'Hara, J., and J. R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. Copeia (2):564-567.

O'Keeffe, D. J. 1984. Guidelines for Predicting the Effects of Underwater Explosions on Swimbladder Fish. Pages 1–28 *in*. Naval Surface Weapons Center, Dahlgren, VA.

O'Keeffe, D. J., and G. A. Young. 1984. Handbook on the Environmental Effects of Underwater Explosions. U.S. Navy, Naval Surface Weapons Center (Code R14), NSWC TR 83-240, Silver Spring, MD.

O'Malley, M. p., K. A. Townsend, P. Hilton, S. Heinrichs, and J. D. Stewart. 2017. Characterization of the trade in manta and devil ray gill plates in China and South-east Asia through trader surveys. Aquatic Conservation: Marine and Freshwater Ecosystems 27(2):394-413.

Ocean Alliance. 2010. The voyage of the Odyssey: Executive summary.

Ocean Conservancy. 2010. Trash travels: from our hands to the sea, around the globe, and through time. The Ocean conservancy.

Office, J. G. P. 2010. Guam and CNMI Military Relocation Final Environmental Impact Statement. Naval Facilities Engineering Command, Pacific.

Ohsumi, S., and S. Wada. 1972. Stock assessment of blue whales in the North Pacific. Working Paper for the 24th Meeting of the International Whaling Commission. 20 pp.

Ohsumi, S., and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. Report of the International Whaling Commission 24:114-126.

Oleson, E. M., and coauthors. 2015. Analysis of long-term acoustic datasets for baleen whales and beaked whales within the Mariana Islands Range Complex (MIRC) for 2010 to 2013. NMFS, Pacific Islands Fisheries Science Center, Honolulu, HI.

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., and M. C. Hill. 2010. 2010 report to PACFLT: Report of cetacean surveys in Guam, CNMI, and the high-seas & follow up on 2009 Main Hawaiian Islands CETACEAN SURVEy. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.

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.

Oliveira, E., T. Jefferson, B. Bartley, and A. Bostwick. 2019. Cruise Report, Marine Species Monitoring and and Lookout Effectiveness Study, Submarine Commanders Course, February 2018, Hawaii Range Complex. Commander, U.S. Pacific Fleet, Pearl Harbor, HI.

Olla, B. L. 1962. The perception of sound in small hammerhead sharks *Sphyrna lewini*. University of Hawaii, Honolulu, Hawaii.

Palacios, D. M., M. F. Baumgartner, K. L. Laidre, and E. J. Gregr. 2014. Beyond correlation: Integrating environmentally and behaviourally mediated processes in models of marine mammal distributions. Endangered Species Research 22(3):191-203.

Palka, D. 2012. Cetacean abundance estimates in US northwestern Atlantic Ocean waters from summer 2011 line transect survey. Northeast Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Reference Document 12-29, Woods Hole, Massachusetts.

Parker, D. M., W. J. Cooke, and G. H. Balazs. 2005. Diet of oceanic loggerhead sea turtles (*Caretta caretta*) in the central North Pacific. Fishery Bulletin 103:142-152.

Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. 2009 Office of Naval Research Marine Mammal Program Review. Alexandria, VA.

Parks, S. E., C. W. Clark, and P. L. Tyack. 2007. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. The Journal of the Acoustical Society of America 122(6):3725–3731.

Parks, S. E., M. Johnson, D. Nowacek, and P. L. Tyack. 2011. Individual right whales call louder in increased environmental noise. Biology Letters 7:33–35.

Parsons, J. J. 1972. The hawksbill turtle and the tortoise shell trade. Pages 45-60 *in* Études de géographie tropicale offertes a Pierre Gourou, volume 1. Mouton, Paris.

Patek, S. N. 2002. Squeaking with a sliding joint: Mechanics and motor control of sound production in palinurid lobsters. Journal of Experimental Biology 205:2375-2385.

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.

Pater, L. L. 1981. Gun blast far field peak overpressure contours. Department of the Navy, Naval Surface Weapons Center.

Patino-Martinez, J., A. Marco, L. Quinones, and B. Godley. 2008. Globally significant nesting of the leatherback turtle (*Dermochelys coriacea*) on the Caribbean coast of Colombia and Panama. Biological Conservation 141(8):1982–1988.

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, P. D. 1966. Hearing in the turtle. Journal of Auditory Research 6:453.

Pavan, G., and coauthors. 2000. Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. Journal of the Acoustical Society of America 107(6):3487-3495.

Payne, K. 1985. Singing in humpback whales. Whalewatcher 19(1):3-6.

Payne, K., P. Tyack, and R. Payne. 1983. Progressive changes in the songs of humpback whales (*Megaptera novaeangliae*): A detailed analysis of two seasons in Hawaii. Pages 9-57 *in*

R. Payne, editor. Communication and Behavior of Whales. Westview Press, Boulder, CO.

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.

Perrin, W., and J. Geraci. 2002. Stranding. Pages 1192-1197 *in* B. W. W. Perrin, and J. Thewissen, editors. Encyclopedia of Marine Mannals. Academic Press, San Diego.

Perrin, W. F., B. Würsig, and J. Thewissen. 2009. Encyclopedia of marine mammals. Academic Press.

Perry, S. L., D. P. DeMaster, and G. K. Silber. 1999. The Great Whales: History and Status of Six Species Listed as Endangered Under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1):1-74.

Philipp, E., and K. Fabricius. 2003. Photophysiological stress in scleractinian corals in response to short-term sedimentation. Journal of Experimental Marine Biology and Ecology 287(57-78).

Pike, D. A. 2014. Forecasting the viability of sea turtle eggs in a warming world. Global Change Biology 20(1):7–15.

Pike, D. A., E. A. Roznik, and I. Bell. 2015. Nest inundation from sea-level rise threatens sea turtle population viability. Royal Society Open Science 2(7):150127.

Piniak, W. E. D. 2012. Acoustic ecology of sea turtles: Implications for conservation. Duke University.

Pinto De Sa Alves, L. C., A. Andriolo, A. N. Zerbini, J. L. A. Pizzorno, and P. J. Clapham. 2009. Record of feeding by humpback whales (Megaptera novaeangliae) in tropical waters off Brazil. Marine Mammal Science 25(2):416-419.

Pirotta, E., K. L. Brookes, I. M. Graham, and P. M. Thompson. 2014. Variation in harbour porpoise activity in response to seismic survey noise. Biology Letters 10(5):20131090.

Pirotta, E., and coauthors. 2015. Predicting the effects of human developments on individual dolphins to understand potential long-term population consequences. Proceedings of the Royal Society of London Series B Biological Sciences 282(1818):Article 20152109.

Piscitelli, M. A., and coauthors. 2010. Lung size and thoracic morphology in shallow- and deep-diving cetaceans. Journal of Morphology 271(6):654-673.

Plotkin, P. 2003. Adult migrations and habitat use. Pages 225-241 *in* L. Lutz, J. A. Musick, and J. Wyneken, editors. Biology of sea turtles, volume II. CRC Press, Boca Raton, Florida.

Plotkin, P. T., (Ed). 1995. National Marine Fisheries Service and the U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland.

Polagye, B., J. Wood, C. Bassett, D. Tollit, and J. Thomson. 2011. Behavioral response of harbor porpoises to vessel noise in a tidal strait. Journal of the Acoustical Society of America 129(4):2368.

Polovina, J. J., and coauthors. 2004. Forage and migration habitat of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific Ocean. Fisheries Oceanography 13(1):36-51.

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

Popov, V. V., A. Y. Supin, V. V. Rozhnov, D. I. Nechaev, and E. V. Sysueva. 2014. The limits of applicability of the sound exposure level (SEL) metric to temporal threshold shifts (TTS) in beluga whales, Delphinapterus leucas. Journal of Experimental Biology 217(10):1804-1810.

Popov, V. V., and coauthors. 2013. Hearing threshold shifts and recovery after noise exposure in beluga whales, Delphinapterus leucas. Journal of Experimental Biology 216(9):1587-1596.

Popov, V. V., and coauthors. 2011. Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises Neophocaena phocaenoides asiaeorientalis. Journal of the Acoustical Society of America 130(1):574-584.

Popov, V. V., E. V. Sysueva, D. I. Nechaev, V. V. Rozhnov, and A. Y. Supin. 2017. Influence of fatiguing noise on auditory evoked responses to stimuli of various levels in a beluga whale, Delphinapterus leucas. Journal of Experimental Biology 220(Pt 6):1090-1096.

Popper, A. N., and coauthors. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. Journal of the Acoustical Society of America 122(1):623-635.

Popper, A. N., and coauthors. 2014. ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Acoustical Society of America Press and Springer Briefs in Oceanography, ISSN 2196-1212 ISSN 2196-1220 (electronic)

ISBN 978-3-319-06658-5 ISBN 978-3-319-06659-2 (eBook), New York, NY and London, United Kingdom.

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.

Port Authority of Guam. 2011. Facts and Figures - Maritime Operations. Port Authority of Guam.

Price, E. R., and coauthors. 2004. Size, growth, and reproductive output of adult female leatherback turtles *Dermochelys coriacea*. Endangered Species Research 5:1-8.

Programme, O. F. 2010. Non-target species interactions with the tuna fisheries of the Western and Central Pacific Ocean. Western and Central Pacific Fisheries Commission, Nuku'alofa, Tonga.

Pultz, S., D. O'Daniel, S. Krueger, H. McSharry, and G. H. Balazs. 1999. Marine turtle survey on Tinian, Mariana Islands. Micronesica 32(1):85-94.

Punt, A. E. 2010. Further analyses related to the estimation of the rate of increase for an unknown stock using a Bayesian meta-analysis. IWC Scientific Committee, Agadir, Morocco.

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.

QPIF. 2011. Shark control program: Sharks caught by type, Queensland, 1985-86 to 2010-11. Queensland Primary Industries and Fisheries, Department of Employment, Economic Development and Innovation.

Quick, N., H. Callahan, and A. J. Read. 2017. Two-component calls in short-finned pilot whales (Globicephala macrorhynchus). Marine Mammal Science.

Rankin, C. H., and coauthors. 2009. Habituation revisited: An updated and revised description of the behavioral characteristics of habituation. Neurobiology of Learning and Memory 92(2):135-138.

Rankin, S., and J. Barlow. 2007. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawaiian Islands. Bioacoustics 16(2):137-145.

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.

Raymundo, L., and coauthors. 2019. Successive bleaching events cause mass coral mortality in Guam, Micronesia. Coral reefs 38(4):677-700.

Read, A. J. 2008. The looming crisis: Interactions between marine mammals and fisheries. Journal of Mammalogy 89(3):541-548.

Read, A. J., P. Drinker, and S. Northridge. 2006. Bycatch of marine mammals in U.S. and global fisheries. Conservation Biology 20(1):163-169.

Reeves, R. R., T. D. Smith, E. A. Josephson, P. J. Clapham, and G. Woolmer. 2004. Historical observations of humpback and blue whales in the North Atlantic Ocean: Clues to migratory routes and possibly additional feeding grounds. Marine Mammal Science 20(4):774-786.

Reichmuth, C., J. M. Sills, J. Mulsow, and A. Ghoul. 2019. Long-term evidence of noise-induced permanent threshold shift in a harbor seal (Phoca vitulina). Journal of the Acoustic Society of America 146(4):2552.

Reid, D., and M. Krogh. 1992. Assessment of catches from protective shark meshing off NSW beaches between 1950 and 1990. Marine and Freshwater Research 43(1):283-296.

Reigl, B., R. P. Moyer, B. K. Walker, D. Gilliam, and R. E. Dodge. 2008. A tale of germs, storms, and bombs: geomorphology and coral assemblage structure at Vieques (Puerto Rico) compared to St. Croix (US Virgin Islands). Journal of Coastal Research 2008:1008-1021.

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.

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.

Reneker, J. L., and S. J. Kamel. 2016. Climate change increases the production of female hatchlings at a northern sea turtle rookery. Ecology 97(12):3257–3264.

Resendiz, A., B. Resendiz, W. J. Nichols, J. A. Seminoff, and N. Kamezaki. 1998. First confirmed east-west transpacific movement of a loggerhead sea turtle, *Caretta caretta*, released in Baja California, Mexico. Pacific Science 52(2):151-153.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation, and numbers. . U.S. Marine Mammal Commission, NTIS PB-280-794.

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*.

Richards, Z. T. 2009. Rarity in the coral genus *Acropora*: Implications for biodiversity conservation. James Cook University.

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., R. A. Davids, C. R. Evans, and P. Norton. 1985a. Distribution of bowheads and industrial activity. Pages 255-306 *in* W. J. Richardson, editor. Behavior, disturbance and distribution of bowhead whales *Balaena mysticetus* in the eastern Beaufort Sea, 1980-84. Report from LGL Ecological Research Associates, Inc. for U.S. Minerals Management Service, Bryan, Texas, and Reston, Virginia.

Richardson, W. J., M. A. Fraker, B. Wursig, and R. S. Wells. 1985b. Behavior of bowhead whales Balaena mysticetus summering in the Beaufort Sea: Reactions to industrial activities. Biological Conservation 32(3):195-230.

Richardson, W. J., and coauthors. 1995a. 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.

Richardson, W. J., C. R. G. Jr., C. I. Malme, and D. H. Thomson. 1995b. Marine Mammals and Noise. Academic Press, Inc., San Diego, California.

Richardson, W. J., G. W. Miller, and C. R. Greene. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America 106(4):2281.

Richardson, W. J., and B. Wursig. 1995. Significance of responses and noise impacts. Pages 387-424 *in* W. J. Richardson, C. R. Greene Jr., C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego.

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. Department of Conservation, Wellington, New Zealand.

Ridgway, S. H. 1972. Homeostasis in the aquatic environment. Pages 590-747 *in* S. H. Ridgway, editor. Mammals of the Sea: Biology and Medicine. Charles C. Thomas, Springfield, Illinois.

Ridgway, S. H., and coauthors. 1997. Behavioral responses and temporary shift in masked hearing threshold of bottlenose dolphins, Tursiops truncatus, to 1-second tones of 141 to 201 dB re 1 µPa. U.S. Department of Navy, Naval Command, Control and Ocean Surveillance Center, RDT&E Division, San Diego, California.

Ridgway, S. H., and R. Howard. 1979. Dolphin lung collapse and intramuscular circulation during free diving: Evidence from nitrogen washout. Science 206(4423):1182-1183.

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.

Riegl, B., and G. M. Branch. 1995. Effects of sediment on the energy budgets of four scleractinian (Bourne 1900) and five alcyonacean (Lamouroux 1816) corals. Journal of Experimental Marine Biology and Ecology 186(2):259-275.

Rigg, D. P., S. C. Peverell, M. Hearndon, and J. E. Seymour. 2009. Do elasmobranch reactions to magnetic fields in water show promise for bycatch mitigation? Marine and Freshwater Research 60(9):942-948.

Risch, D., P. J. Corkeron, W. T. Ellison, and S. M. V. Parijs. 2012. Changes in humpback whale song occurrence in response to an acoustic source 200 km away. PloS one 7(1):e29741.

Risch, D., P. J. Corkeron, W. T. Ellison, and S. M. V. Parijs. 2014. Formal comment to Gong et al: Ecosystem scale acoustic sensing reveals humpback whale behavior synchronous with herring spawning processes and re-evaluation finds no effect of sonar on humpback song occurrence in the Gulf of Maine in fall 2006. PLoS One 9(10):e109225.

Rivers, J. A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. Marine Mammal Science 13(2):186-195.

Robertson, F. C. 2014. Effects of Seismic Operations on Bowhead Whale Behavior: Implications for Distribution and Abundance Assessments. The University of British Columbia, Vancouver, BC.

Robinson, R. A., and coauthors. 2005. Climate change and migratory species. Defra Research, British Trust for Ornithology, Norfolk, U.K. .

Rogers, C. S. 1979. The effect of shading on coral reef structure and function. Journal of Experimental Marine Biology and Ecology 41(3):269-288.

Rogers, C. S. 1983. Sublethal and lethal effects of sediments applied to common Caribbean reef corals in the field. Marine Pollution Bulletin 14(10):378-382.

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.

Romano, T. A., and coauthors. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61:1124-1134.

Romero, L. M. 2004. Physiological stress in ecology: Lessons from biomedical research. Trends in Ecology and Evolution 19(5):249-255.

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., and H. Watts. 2008. Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico. Gulf of Mexico Science 25(1):88–94.

Royer, T. C. 2005. Hydrographic responses at a coastal site in the northern Gulf of Alaska to seasonal and interannual forcing. Deep-Sea Research Part Ii-Topical Studies in Oceanography 52(1-2):267-288.

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.

Saez, L., and coauthors. 2013. Understanding the co-occurrence of large whales and commercial fixed gear fisheries off the west coast of the United States. NOAA, National Marine Fisheries Service, Southwest Region.

Saez, L., and coauthors. 2012. Co-occurrence of large whales and fixed commercial fishing gear: California, Oregon, and Washington. Southern California Marine Mammal Workshop, Newport Beach, California.

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.

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.

Sarti-Martinez, A. L. 2000. *Dermochelys coriacea*. IUCN Red List of Threatened Species.

Sarti M., L. 1996. A note about declining leatherbacks in Mexico. Marine Turtle Newsletter 75:25-26.

Saunders, K. J., P. R. White, and T. G. Leighton. 2008. Models for predicting nitrogen tensions in diving odontocetes. Pages 88 *in* Twenty Second Annual Conference of the European Cetacean Society, Egnond aan Zee, The Netherlands.

Schakner, Z. A., and D. T. Blumstein. 2013. Behavioral biology of marine mammal deterrents: A review and prospectus. Biological Conservation 167:380-389.

Scheifele, P. M., and coauthors. 2005. Indication of a Lombard vocal response in the St. Lawrence River beluga. Journal of the Acoustical Society of America 117(3):1486-1492.

Schevill, W. E., W. A. Watkins, and R. H. Backus. 1964. The 20-cycle signals and *Balaenoptera* (fin whales). Pages 147-152 *in* W. N. Tavolga, editor Marine Bio-acoustics. Pergamon Press, Lerner Marine Laboratory, Bimini, Bahamas.

Schils, T., and coauthors. 2011. Coral reef monitoring Kilo Wharf extension Apra Harbor, Guam. University of Guam, Marine Laboratory.

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. Journal of the Acoustical Society of America 107(6):3496-3508.

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.

Schorr, G., E. A. Falcone, D. J. Moretti, and R. Andrews. 2014. First long-term behavioral records from Cuvier's beaked whales (Ziphius cavirostris) reveal record-breaking dives. PLoS ONE, 9(3), e92633. .

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., B. D. Hardesty, C. Wilcox, and K. Townsend. 2012. To eat or not to eat? Debris selectivity by marine turtles. PloS one 7(7):e40884.

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.

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.

Seminoff, J. A., and coauthors. 2014. Loggerhead sea turtle abundance at a foraging hotspot in the eastern Pacific Ocean: Implications for at-sea conservation. Endangered Species Research 24(3):207-220.

Settle, L. R., and coauthors. 2002. Investigation of impacts of underwater explosions on larval and early juvenile fishes.

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.

Shine, R., X. Bonnet, M. J. Elphick, and E. G. Barrott. 2004. A novel foraging mode in snakes: browsing by the sea snake *Emydocephalus annulatus* (Serpentes, Hydrophiidae). Functional Ecology 18(1):16–24.

Shoop, C. R., and R. D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

Silber, G. K. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). Canadian Journal of Zoology 64(10):2075-2080.

Silber, G. K., and coauthors. 2017. Projecting Marine Mammal Distribution in a Changing Climate. Frontiers in Marine Science 4:14.

Simao, S. M., and S. C. Moreira. 2005. Vocalizations of a female humpback whale in Arraial do Cabo (Rj, Brazil). Marine Mammal Science 21(1):150-153.

Simmonds, M. P., and W. J. Eliott. 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.

Simonis, A. E., and coauthors. 2020. Co-occurrence of beaked whale strandings and naval sonar in the Mariana Islands, Western Pacific. Proceedings of the Royal Society B 287(1921):20200070.

Sims, P. Q., S. K. Hung, and B. Wursig. 2012. High-speed vessel noises in West Hong Kong waters and their contributions relative to Indo-Pacific humpback dolphins (*Sousa chinensis*). Journal of Marine Biology 2012:11.

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.

Sirovic, A., L. N. Williams, S. M. Kerosky, S. M. Wiggins, and J. A. Hildebrand. 2012. Temporal separation of two fin whale call types across the eastern North Pacific. Marine Biology 160(1):47-57.

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.

Smith, B. D., and coauthors. 2009. Marine biological survey of inner Apra Harbor, Guam. University of Guam, Marine Laboratory.

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, J. N., A. W. Goldizen, R. A. Dunlop, and M. J. Noad. 2008. Songs of male humpback whales, Megaptera novaeangliae, are involved in intersexual interactions. Animal Behaviour 76(2):467-477.

Smith, J. N., and coauthors. 2020. Quantifying Ship Strike Risk to Breeding Whales in a Multiple-Use Marine Park: The Great Barrier Reef. Frontiers in Marine Science 7.

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, S. H., D. E. Marx Jr., and L. H. Shannon. 2013. Calendar year 2012 assessment of near shore marine resources at Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Department of the Navy, NAVFAC-EXWC SDS.

Smultea, M. A., C. E. Bacon, and J. S. D. Black. 2011. Aerial Survey Marine Mammal Monitoring off Southern California in Conjunction with US Navy Major Training Events (MTE), July 27- August 3 and September 23–28, 2010—Final Report, June 2011. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, HI. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, HI, 96860 3134, under Contract No. N00244-10-C-0021 issued to University of California, San Diego, 7835 Trade St., San Diego, CA 92121. Submitted by Smultea Environmental Sciences (SES), Issaquah, WA, 98027, www.smultea.com, under Purchase Order No. 10309963.

Smultea, M. A., C. E. Bacon, T. F. Norris, and D. Steckler. 2012. Aerial Surveys Conducted in the SOCAL OPAREA From 1 August 2011–31 July 2012. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, HI. Submitted to Naval Facilities Engineering Command Southwest (NAVFAC SW), EV5 Environmental, San Diego, 92132 under Contract No. N62470-10-D-3011 issued to HDR, Inc., San Diego, CA. Submitted August 2012.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis. 2010. Rare sightings of a bryde's whale (*Balaenoptera edeni*) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i. Pacific Science 64(3):449-457.

Smultea, M. A., and J. R. Mobley. 2009. Aerial Survey Monitoring of Marine Mammals and Sea Turtles in conjunction with SCC OPS Navy Exercises off Kauai, 18–21 August 2008, Final Report, May 2009. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, HI. Prepared by Marine Mammal Research Consultants, Honolulu, HI, and Smultea Environmental Sciences, LLC., Issaquah, WA, under Contract No. N62742-08-P-1942.

Smultea, M. A., J. R. Mobley, D. Fertl, and G. L. Fulling. 2008. An unusual reaction and other observationis 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.

Snoddy, J. E., M. Landon, G. Blanvillain, and A. Southwood. 2009. Blood biochemistry of sea turtles captured in gillnets in the lower Cape Fear River, North Carolina, USA. Journal of Wildlife Management 73(8):1394–1401.

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.

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. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):122.

Southall, B., and coauthors. 2013. Measuring cetacean reponses 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., and coauthors. 2011. Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2010 ("SOCAL -10").

Southall, B. L., and coauthors. 2019. Behavioral responses of individual blue whales (Balaenoptera musculus) to mid-frequency military sonar. Journal of Experimental Biology 222(Pt 5).

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.

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.

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

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.

St. Aubin, D. J., and J. R. Geraci. 1989. Adaptive changes in hematologic and plasma chemical constituents in captive beluga whales, Delphinapterus leucas. Canadian Journal of Fisheries and Aquatic Sciences 46:796-803.

St. Aubin, D. J., S. H. Ridgway, R. S. Wells, and H. Rhinehart. 1996. Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated Tursiops truncatus, and influence of sex, age, and season. Marine Mammal Science 12(1):13-Jan.

Stabeno, P. J., and coauthors. 2004. Meteorology and oceanography of the northern Gulf of Alaska. Continental Shelf Research 24-Jan(8-Jul):859-897.

Stafford-Smith, M. G. 1993. Sediment-rejection efficiency of 22 species of Australian scleractinian corals. Marine Biology 115(2):229-243.

Stafford-Smith, M. G., and R. F. G. Ormond. 1992. Sediment-rejection mechanisms of 42 species of Australian scleractinian corals. Marine and Freshwater Research 43(4):683-705.

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.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific (*Balaenoptera musculus*). Journal of Cetacean Research and Management 3(1):65-76.

Starmer, J. 2008. Coral community assessment at Kilo Wharf, Apra Harbor, Guam. Pacific Marine Resources Institute, Saipan.

Stensland, E., and P. Berggren. 2007. Behavioural changes in female Indo-Pacific bottlenose dolphins in response to boat-based tourism. Marine Ecology Progress Series 332:225-234.

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.

Stimpert, A. K., and coauthors. 2014. Acoustic and foraging behavior of a Baird's beaked whale, Berardius bairdii, exposed to simulated sonar. Scientific Reports 4(7031):8.

Stimpert, A. K., D. N. Wiley, W. W. L. Au, M. P. Johnson, and R. Arsenault. 2007. 'Megapclicks': Acoustic click trains and buzzes produced during night-time foraging of humpback whales (Megaptera novaeangliae). Biology Letters 3(5):467-470.

Stockin, K., D. Lusseau, V. Binedell, N. Wiseman, and M. Orams. 2008. Tourism affects the behavioural budget of the common dolphin *Delphinus* sp. in the Hauraki Gulf, New Zealand. Marine Ecology Progress Series 355:287-295.

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.

Suarez, A., P. H. Dutton, and J. Bakarbessy. 2000. Leatherback (*Dermochelys coriacea*) nesting on the north Vogelkop coast of Irian Jaya, Indonesia. Pages 260 *in* H. Kalb, and T. Wibbels, editors. Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center.

Sullivan, R. 2019. Sperm whale found dead with 220 pounds of trash in its stomach. CNN, https://www.cnn.com/2019/12/02/world/dead-sperm-whale-ball-of-debris-scli-intl-gbr/index.html.

Summers, T., I. Kelly, T. Work, J. Ruak, and J. Hapdei. 2018a. Human induced trauma and directed take inhibits sea turtle recovery in the Commonwealth of the Northern Mariana Islands. Micronesica 2018-08: 1–19.

Summers, T. M., and coauthors. 2017. Demography of marin turtles in the nearshore environments of the Northern Mariana Islands. Pacific Science 71(3):269-286.

Summers, T. M., S. L. Martin, J. R. Hapdei, J. K. Ruak, and T. T. Jones. 2018b. Endangered green turtles (Chelonia mydas) of the Northern Mariana Islands: Nesting ecology, poaching, and climate concerns. Frontiers in Marine Science 4:428.

Sutherland, A. J., and D. G. Ogle. 1975. Effect of jet boats on salmon eggs. New Zealand Journal of Marine and Freshwater Research 9(3):273-282.

Swope, B., and J. McDonald. 2013. Copper-Based Torpedo Guidance Wire: Applications and Environmental Considerations. San Diego, CA.

Szmant, A. M. 1986. Reproductive ecology of Caribbean reef corals. Coral Reefs 5(1):43-53.

Tagarino, A., K. S. Saili, and R. Utzurrum. 2008. Investigations into the Status of Marine Turtles in American Samoa, with Remediation of Identified Threats and Impediments to Conservation and Recovery of Species. NOAA/NMFS Unallied Management Grant # NA04NMF4540126. Final Report: 01 October 2004 to 30 September 2008. 43 pp.

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.

Tapilatu, R. F., and coauthors. 2013. Long-term decline of the western Pacific leatherback, *Dermochelys coriacea*: A globally important sea turtle population. Ecosphere 4:15.

Tech, T. 2014. Coral Marine Resources Survey Report in support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared for Naval Facilities Engineering Command, Pacific.

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.

Terhune, J. M., and W. C. Verboom. 1999. Right whales and ship noises. Marine Mammal Science 15(1):256-258.

TEWG. 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Turtle Expert Working Group.

Thode, A., J. Straley, C. O. Tiemann, K. Folkert, and V. O'Connell. 2007. Observations of potential acoustic cues that attract sperm whales to longline fishing in the Gulf of Alaska. Journal of the Acoustical Society of America 122(2):1265-1277.

Thomas, J. A., R. A. Kastelein, and F. T. Awbrey. 1990. Behavior and blood catecholamines of captive belugas during playbacks of noise from ships and oil drilling platform. Zoo Biology 9(5):393-402.

Thomas, P. O., R. R. Reeves, and R. L. Brownell. 2016. Status of the world's baleen whales. Marine Mammal Science 32(2):682-734.

Thompson, P. M., and coauthors. 2013. Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. Proceedings of the Royal Society B 280(1771):20132001.

Thompson, P. M., and coauthors. 2010. Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. Marine Pollution Bulletin 60(8):1200–1208.

Thompson, P. O., W. C. Cummings, and S. J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. Journal of the Acoustical Society of America 80(3):735-740.

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, T. J., H. E. Winn, and P. J. Perkins. 1979. Mysticete sounds. Pages 403-431 *in* H. E. Winn, and B. L. Olla, editors. Behavior of Marine Animals: Current Perspectives in Research, volume 3 Cetaceans. Plenum Press, New York.

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.

Tillman, M. F. 1977. Estimates of population size for the North Pacific sei whale. Report of the International Whaling Commission (Special Issue 1):98-106.

Tixier, P., N. Gasco, G. Duhamel, and C. Guinet. 2014. Habituation to an acoustic harassment device (AHD) by killer whales depredating demersal longlines. ICES Journal of Marine Science, 72(5), 1673–1681. .

Todd, S., P. Stevick, J. Lien, F. Marques, and D. Ketten. 1996. Behavioural effects of exposure to underwater explosions in humpback whales (*Megaptera novaeanlgiae*). Canadian Journal of Zoology 74:1661–1672.

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).

Tomás, J., P. Gozalbes, J. A. Raga, and B. J. Godley. 2008. Bycatch of loggerhead sea turtles: insights from 14 years of stranding data. Endangered Species Research 5(2-3):161-169.

Tonnessen, J. N., and A. O. Johnsen. 1982. The History of Modern Whaling. University of California Press, Berkeley, California.

Tougaard, J., and coauthors. 2005. Effects of the Nysted Offshore wind farm on harbour porpoises.

Tougaard, J., J. Carstensen, J. Teilmann, H. Skov, and P. Rasmussen. 2009. Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (*Phocoena phocoena* (L.)). Journal of the Acoustical Society of America 126(1):11.

Tremblay, C. J., S. M. Van Parijs, and D. Cholewiak. 2019. 50 to 30-Hz triplet and singlet down sweep vocalizations produced by sei whales (Balaenoptera borealis) in the western North Atlantic Ocean. The Journal of the Acoustical Society of America 145(6):3351.

Trickey, J. S., and coauthors. 2015. Passive Acoustic Monitoring for Marine Mammals in the Northwest Training Range Complex July 2013–April 2014. La Jolla, CA: Marine Physical Laboratory Scripps Institution of Oceanography University of California San Diego.

Tseng, Y.-P., Y.-C. Huang, G. T. Kyle, and M.-C. Yang. 2011. Modeling the impacts of cetacean-focused tourism in Taiwan: Observations from cetacean watching boats: 2002-2005. Environmental Management 47(1):56-66.

Tyack, P. 1983. Differential response of humpback whales, Megaptera novaeangliae, to playback of song or social sounds. Behavioral Ecology and Sociobiology 13(1):49-55.

Tyack, P., and coauthors. 2011a. Response of Dtagged Cuvier's beaked whale, Ziphius cavirostris, to controlled exposure of sonar sound. Pages 297 *in* Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

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., M. Johnson, N. Aguilar Soto, A. Sturlese, and P. T. Madsen. 2006. Extreme deep diving of beaked whales. Journal of Experimental Biology 209:4238-4253.

Tyack, P. L., and coauthors. 2011b. Beaked whales respond to simulated and actual Navy sonar. PloS one 6(3):e17009.

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. Navy. 2010. Annual Range Complex Exercise Report 2 August 2009 to 1 August 2010 U.S. Navy Southern California (SOCAL) Range Complex and Hawaii Range Complex (HRC)

U.S. Navy. 2012. Marine Species Monitoring for the U.S. Navy's Southern California Range Complex- Annual Report 2012. U.S. Pacific Fleet, Environmental Readiness Division, U.S. Department of the Navy, Pearl Harbor, HI.

Urick, R. J. 1983. Principles of Underwater Sound, Principles of Underwater Sound for Engineers, 3rd edition. Peninsula Publishing, Los Altos Hills, CA.

USFWS. 2012. Hawksbill Sea Turtle Fact Sheet.

Uyeyama, R. 2014. Compilation of Incidental Marine Mammal and Sea Turtle Sightings in the Mariana Islands Range Complex. Commander, U.S. Pacific Fleet, Pearl Harbor, HI.

Vallejo, G. C., and coauthors. 2017. Responses of two marine top predators to an offshore wind farm. Ecology and Evolution 7(21):8698–8708.

van Beest, F. M., L. Kindt-Larsen, F. Bastardie, V. Bartolino, and J. Nabe-Nielsen. 2017. Predicting the population-level impact of mitigating harbor porpoise bycatch with pingers and time-area fishing closures. Ecosphere 8(4):e01785.

Van Hooidonk, R., and coauthors. 2016. Local-scale projections of coral reef futures and implications of the Paris Agreement. Scientific Reports 6(1):39666.

Van Parijs, S. M., and P. J. Corkeron. 2001. Boat traffic affects the acoustic behaviour of Pacific humpback dolphins, Sousa chinensis. Journal of the Marine Biological Association of the UK 81(3):6.

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.

Vermeij, M. J. A., K. L. Marhaver, C. M. Huijbers, I. Nagelkerken, and S. D. Simpson. 2010. Coral larvae move towards reef sounds. PloS one 5(5):e10660.

Veron, J. E. N. 2000. Corals of the World. Australian Institute of Marine Science 1.

Veron, J. E. N. 2014. Results of an update of the corals of the world information base for the listing determination of 66 coral species under the Endangered Species Act. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

Videsen, S. K. A., L. Bejder, M. Johnson, P. T. Madsen, and J. Goldbogen. 2017. High suckling rates and acoustic crypsis of humpback whale neonates maximise potential for mother-calf energy transfer. Functional Ecology.

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, G. Gailey, O. Sychenko, and D. P. Costa. 2017. East or west: The energetic cost of being a gray whale and the consequence of losing energy to disturbance. Endangered Species Research 34:167–183.

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).

Visser, F., and coauthors. 2016. Disturbance-specific social responses in long-finned pilot whales, *Globicephala melas*. Scientific Reports 6:28641.

von Benda-Beckmann, A., and coauthors. 2016. Assessing the Effectiveness of Ramp-Up During Sonar Operations Using Exposure Models The Effects of Noise on Aquatic Life II (pp. 1197–1203). New York, NY: Springer.

von Benda-Beckmann, A. M., and coauthors. 2014. Modeling effectiveness of gradual increases in source level to mitigate effects of sonar on marine mammals. Conservation Biology 28(1):119-128.

Vu, E. T., C. Clark, K. Catelani, N. M. Kellar, and J. Calambokidis. 2015. Seasonal blubber testosterone concentrations of male humpback whales (Megaptera novaeangliae). Mar Mam Sci 31(3):1258-1264.

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.

Walker, R. J., E. O. Keith, A. E. Yankovsky, and D. K. Odell. 2005. Environmental correlates of cetacean mass stranding sites in Florida. Marine Mammal Science 21(2):327-335.

Walker, W. A., and J. M. Coe. 1990. Survey of marine debris ingestion by odontocete cetaceans. Pages 747-774 *in* Second International Conference on Marine Debris, Honolulu, Hawaii.

Wallace, B. P., S. S. Kilham, F. V. Paladino, and J. R. Spotila. 2006. Energy budget calculations indicate resource limitation in Eastern Pacific leatherback turtles. Marine Ecology Progress Series 318:263-270.

Wallace, B. P., and coauthors. 2010. Global patterns of marine turtle bycatch: Identification of conservation and research priorities. Pages 86 *in* J. Blumenthal, A. Panagopoulou, and A. F. Rees, editors. Thirtieth Annual Symposium on Sea Turtle Biology and Conservation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Goa, India.

Wallace, B. P., and coauthors. 2007. Maternal investment in reproduction and its consequences in leatherback turtles. Oecologia 152(1):37-47.

Wallace, B. P., Tiwari, M., Girondot, M. 2013. *Dermochelys coriacea* IUCN Red List of Threatened Species. Version 2013.2.

Wallace, C. 1985. Reproduction, recruitment and fragmentation in nine sympatric species of the coral genus *Acropora*. Marine Biology 88(3):217-233.

Wallace, C. C. 1999. Staghorn corals of the world: a revision of the coral genus *Acropora* (Scleractinia; Astroceoniina; Acroporidae) worldwide, with emphasis on morphology, phylogeny and biogeography. C. Publishing, editor, Collingwood, Australia.

Wang, W. X., and P. S. Rainbow. 2008. Comparative approaches to understand metal bioaccumulation in aquatic animals. Comparative Biochemistry and Physiology, Part C 148(4):315–323.

Ward, D. W. 1960. Recovery from high values of temporary threshold shift. Journal of the Acoustical Society of America, 32(4), 497–500. .

Ward, S. L., and J. W. Clark. 1943. The effects of rapid compression waves on animals submerged in water. Surgery, Gynecology and Obstetrics 77:403-412.

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. 1981a. Activities and underwater sounds of fin whales (*Balaenoptera physalus*). Scientific Reports of the Whales Research Institute Tokyo 33:83-118.

Watkins, W. A. 1981b. Reaction of three species of whales, *Balaenoptera physalus*, *Megaptera novaeangliae*, and *Balaenoptera edeni* to implanted radio tags. Deep Sea Research Part I: Oceanographic Research Papers 28(6):589-599.

Watkins, W. A. 1985. Changes observed in the reaction of whales to human activities. National Oceanic and Atmospheric Administration, 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., 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 Oceanogaphic 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. L., M. M. Yoklavich, M. S. Love, and D. M. Schroeder. 2010. Assessing marine debris in deep seafloor habitats off California. Marine Pollution Bulletin 60:131-138.

Watwood, S., M. Fagain, A. D'Amico, and T. Jefferson. 2012. Cruise Report, Marine Species Monitoring and Lookout Effectiveness Study, Koa Kai, November 2011, Hawaii Range Complex. Prepared for Commander, U.S. Pacific Fleet.

Weaver, A. 2015. Sex difference in bottlenose dolphin sightings during a long-term bridge construction project. Animal Behavior and Cognition 2(1):1–13.

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.

Weinrich, M. T., J. Bove, and N. Miller. 1993. Return and survival of humpback whale (*Megaptera novaeangliae*) calves born to a single female in three consecutive years. Marine Mammal Science 9(3):325-328.

Weinrich, M. T., and coauthors. 1992. Behavioral reactions of humpback whales *Megaptera novaeangliae* to biopsy procedures. Fishery Bulletin 90:588-598.

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., and coauthors. 2017. Spatial and temporal trends in fin whale vocalizations recorded in the NE Pacific Ocean between 2003-2013. PLoS One 12(10):e0186127.

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., and coauthors. 2018. Movement, Behavior, and Habitat Use of a Marine Apex Predator, the Scalloped Hammerhead. Frontiers in Marine Science 5:321.

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. 2015. How effectively do horizontal and vertical response strategies of long-finned pilot whales reduce sound exposure from naval sonar? Marine Environmental Research 106:68-81.

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. W., and coauthors. 2020. Humpback Whales (Megaptera novaeangliae) in the Cape Verde Islands: Migratory Patterns, Resightings, and Abundance. Aquatic Mammals.

Wever, E. G., and J. A. Vernon. 1956. The sensitivity of the turtle's ear as shown by its electrical potentials. Proceedings of the National Academy of Sciences of the United States of America 42:213-222.

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. Sperm Whales: Social Evolution in the Ocean. University of Chicago 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., J. Christal, and S. Dufault. 1997. Past and distant whaling and the rapid decline of sperm whales off the Galapagos Islands. (Physeter macrocephalus). Conservation Biology 11(6):1387-1396.

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.

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.

Wiley, M. L., J. B. Gaspin, and J. F. Goertner. 1981. Effects of underwater explosions on fish with a dynamical model to predict fishkill. Ocean Science and Engineering 6(2):223–284.

Williams, R., and E. Ashe. 2007. Killer whale evasive tactics vary with boat number. (Orcinus orca). Journal of Zoology 272(4):390-397.

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. 2002a. Behavioural responses of male killer whales to a 'leapfrogging' vessel. Journal of Cetacean Research and Management 4(3):305-310.

Williams, R., and D. P. Noren. 2009. Swimming speed, respiration rate, and estimated cost of transport in adult killer whales. Marine Mammal Science 25(2):327-350.

Williams, R. M., A. W. Trites, and D. E. Bain. 2002b. Behavioral responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. Journal of Zoology 256(2):255-270.

Williams, T. M., and coauthors. 2017. Swimming and diving energetics in dolphins: a stroke-by-stroke analysis for predicting the cost of flight responses in wild odontocetes. Journal of Experimental Biology 220(6):1135–1145.

Willis-Norton, E., and coauthors. 2015. Climate change impacts on leatherback turtle pelagic habitat in the Southeast Pacific. Deep Sea Research Part II: Topical Studies in Oceanography 113:260-267.

Winn, H. E., P. J. Perkins, and T. C. Poulter. 1970. Sounds of the humpback whale. Proceedings of the 7th Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute Menlo Park CA. p.39-52.

Witherington, B. E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica 48(1):31-39.

Witherington, B. E., and K. A. Bjorndal. 1991. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta caretta*. Biological Conservation 55(2):139-149.

Witt, M. J., and coauthors. 2009. Aerial surveying of the world's largest leatherback turtle rookery: A more effective methodology for large-scale monitoring. Biological Conservation 142(8):1719-1727.

Witt, M. J., L. A. Hawkes, M. H. Godfrey, B. J. Godley, and A. C. Broderick. 2010. Predicting the impacts of climate change on a globally distributed species: The case of the loggerhead turtle. The Journal of Experimental Biology 213(6):901–911.

Witteveen, B. H., and coauthors. 2011. Trophic levels of North Pacific humpback whales (*Megaptera novaeangliae*) through analysis of stable isotopes: Implications on prey and resource quality. Aquatic Mammals 37(2):101-110.

Witzell, W. N., A. A. Geis, J. R. Schmid, and T. Wibbels. 2005. Sex ratio of immature Kemp's ridley turtles (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, south-west Florida. Journal of the Marine Biological Association of the U.K. 85:205-208.

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.

Wright, D. G. 1982. A Discussion Paper on the Effects of Explosives on Fish and Marine Mammals in the Waters of the Northwest Territories. Western Region Department of Fisheries and Oceans, Winnipeg, Canada.

Wursig, B., S. K. Lynn, T. A. Jefferson, 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.

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.

Yack, T. M., T. F. Norris, and N. Novak. 2016. Acoustic Based Habitat Models for Sperm Whales in the Mariana Islands Region. Bio-Waves, Inc., Encinitas, CA.

Yagla, J., and R. Stiegler. 2003. Gun blast noise transmission across the air-sea interface. Pages 9-Jan *in* Euronoise, Naples.

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., and D. R. Richmond. 1981. Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals. Pages S84 *in* 102nd Meeting of the Acoustical Society of America. Miami Beach, FL. Journal of the Acoustical Society of America.

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.

Yelverton, J. T., D. R. Richmond, W. Hicks, K. Saunders, and E. R. Fletcher. 1975. The Relationship between Fish Size and Their Response to Underwater Blast. Lovelace Foundation for Medical Education and Research, DNA 3677T, Washington, DC.

Yochem, P. K., and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). In: Ridgway SH, Harrison R, editors. Handbook of Marine Mammals, vol. 3: The Sirenians and Baleen Whales.:London: Academic Press. p 193-240.

Young, C. N., and coauthors. 2017. Status review report: oceanic whitetip shark (*Carcharhinius longimanus*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

Yudhana, A., Sunardi, J. Din, S. Abdullah, and R. B. R. Hassan. 2010. Turtle hearing capability based on ABR signal assessment. Telkomnika 8:187- 194.

Zellar, R., and coauthors. 2017. Statistical Assessment of Cetacean Stranding Events in Cape Cod (Massachusetts, USA) Area OS21A-1345. National Aeronautics and Space Administration, Greenbelt, MD.

Zimmer, W. M. X., and P. L. Tyack. 2007. Repetitive shallow dives pose decompression risk in deep-diving beaked whales. Marine Mammal Science 23(4):888-925.

Zoidis, A. M., and coauthors. 2008. Vocalizations produced by humpback whale (*Megaptera novaeangliae*) calves recorded in Hawaii. The Journal of the Acoustical Society of America 123(3):1737-1746.