REQUEST FOR REGULATIONS AND LETTERS OF AUTHORIZATION

FOR THE INCIDENTAL TAKING OF MARINE MAMMALS RESULTING FROM U.S. NAVY TRAINING AND TESTING ACTIVITIES IN THE NORTHWEST TRAINING AND TESTING STUDY AREA

Submitted to:

Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, Maryland 20910-3226

Submitted by:

Commander, United States Pacific Fleet
250 Makalapa Drive
Joint Base Pearl Harbor-Hickam, HI 96860-3131

Navy System Commands
(Naval Sea Systems Command and Naval Air Systems Command),
as Represented By Commander, Naval Sea Systems Command
1333 Isaac Hull Avenue, SE
Washington Navy Yard, DC 20376

Revised 21 June 2019

1

TABLE OF CONTENTS

1 DESCRIPTION OF SPECIFIED ACTIVITY 1

1.1 INTRODUCTION 1
1.2 BACKGROUND 4
1.3 OVERVIEW OF TRAINING AND TESTING ACTIVITIES 4
1.3.1 Primary Mission Areas 4
1.3.1.1 Anti-Submarine Warfare 5
1.3.1.2 Expeditionary Warfare 6
1.3.1.3 Mine Warfare 6
1.3.1.4 Surface Warfare 6
1.3.1.5 Other Activities 7
1.3.2 Overview of Navy Activities Within the Study Area 7
1.4 DESCRIPTION OF ACOUSTIC AND EXPLOSIVE STRESSORS 8
1.4.1 Acoustic Stressors 8
1.4.1.1 Sonar and Other Transducers 9
1.4.2 Explosive Stressors 12
1.4.2.1 Explosions in Water 13
1.5 PROPOSED ACTION 14
1.5.1 Training and Testing Activities 14
1.5.2 Summary of Acoustic and Explosive Sources Analyzed for Training and Testing 22
1.5.3 Vessel Movements 26
1.5.4 Standard Operating Procedures 27
1.5.5 Mitigation Measures 28

2 DATES, DURATION, AND SPECIFIED GEOGRAPHIC REGION 30

2.1 OFFSHORE AREA 31
2.1.1 Airspace 31
2.1.2 Sea and Undersea Space 32
2.2 INLAND WATERS 32
2.2.1 Airspace 32
2.2.2 Sea and Undersea Space 36
2.2.2.1 Explosive Ordnance Disposal Underwater Ranges 36
2.2.2.2 Surface and Subsurface Testing Sites 36
2.2.2.3 Pierside Testing Facilities 37
2.2.2.4 Navy Surface Operations Areas 37
2.3 WESTERN BEHM CANAL, ALASKA 37

3 SPECIES AND NUMBERS OF MARINE MAMMALS 40

3.1 SPECIES KNOWN TO OCCUR IN THE STUDY AREA 40
3.2 SPECIES UNLIKELY TO OCCUR IN THE STUDY AREA 40

4 AFFECTED SPECIES STATUS AND DISTRIBUTION 44

4.1 MYSTICETES 44
4.1.1 Blue Whale (Balaenoptera musculus) 44
4.1.1.1 Status and Management 44
4.1.1.2 Geographic Range and Distribution 44
4.1.1.3 Population and Abundance 46
4.1.2 Fin Whale (Balaenoptera physalus) 47
4.1.2.1 Status and Management 47

4.1.2.2 Geographic Range and Distribution 47
4.1.2.3 Population and Abundance 48
4.1.3 Gray Whale (Eschrichtius robustus) 48
4.1.3.1 Status and Management 48
4.1.3.2 Geographic Range and Distribution 49
4.1.3.3 Population and Abundance 52
4.1.4 Humpback Whale (Megaptera novaeangliae) 53
4.1.4.1 Status and Management 53
4.1.4.2 Geographic Range and Distribution 54
4.1.4.3 Population and Abundance 56
4.1.5 Minke Whale (Balaenoptera acutorostrata) 56
4.1.5.1 Status and Management 56
4.1.5.2 Geographic Range and Distribution 56
4.1.5.3 Population and Abundance 57
4.1.6 North Pacific Right Whale (Eubalaena japonica) 58
4.1.6.1 Status and Management 58
4.1.6.2 Geographic Range and Distribution 58
4.1.6.3 Population and Abundance 59
4.1.7 Sei Whale (Balaenoptera borealis) 59
4.1.7.1 Status and Management 59
4.1.7.2 Geographic Range and Distribution 59
4.1.7.3 Population and Abundance 60
4.2 ODONTOCETES 60
4.2.1 Baird's Beaked Whale (Berardius bairdii) 60
4.2.1.1 Status and Management 60
4.2.1.2 Geographic Range and Distribution 60
4.2.1.3 Population and Abundance 61
4.2.2 Common Bottlenose Dolphin (Tursiops truncatus) 61
4.2.2.1 Status and Management 61
4.2.2.2 Geographic Range and Distribution 61
4.2.2.3 Population and Abundance 62
4.2.3 Cuvier's Beaked Whale (Ziphius cavirostris) 62
4.2.3.1 Status and Management 62
4.2.3.2 Geographic Range and Distribution 62
4.2.3.3 Population and Abundance 63
4.2.4 Dall's Porpoise (Phocoenoides dalli) 63
4.2.4.1 Status and Management 63
4.2.4.2 Geographic Range and Distribution 63
4.2.4.3 Population and Abundance 64
4.2.5 Dwarf Sperm Whale (Kogia sima) 64
4.2.5.1 Status and Management 64
4.2.5.2 Geographic Range and Distribution 65
4.2.5.3 Population and Abundance 65
4.2.6 Harbor Porpoise (Phocoena phocena) 65
4.2.6.1 Status and Management 65
4.2.6.2 Geographic Range and Distribution 65
4.2.6.3 Population and Abundance 66
4.2.7 Killer Whale (Orcinus orca) 66
4.2.7.1 Status and Management 66
4.2.7.2 Geographic Range and Distribution 68
4.2.7.3 Population and Abundance 70
4.2.8 Mesoplodont Beaked Whales (Mesoplodon spp.) 70

4.2.8.1 Status and Management 70
4.2.8.2 Geographic Range and Distribution 71
4.2.8.3 Population and Abundance 72
4.2.9 Northern Right Whale Dolphin (Lissodelphis borealis) 72
4.2.9.1 Status and Management 72
4.2.9.2 Geographic Range and Distribution 73
4.2.9.3 Population and Abundance 73
4.2.10 Pacific White-Sided Dolphin (Lagenorhynchus obliquidens) 73
4.2.10.1 Status and Management 73
4.2.10.2 Geographic Range and Distribution 74
4.2.10.3 Population and Abundance 74
4.2.11 Pygmy Sperm Whale (Kogia breviceps) 75
4.2.11.1 Status and Management 75
4.2.11.2 Geographic Range and Distribution 75
4.2.11.3 Population and Abundance 75
4.2.12 Risso's Dolphin (Grampus griseus) 75
4.2.12.1 Status and Management 75
4.2.12.2 Geographic Range and Distribution 76
4.2.12.3 Population and Abundance 76
4.2.13 Short-Beaked Common Dolphin (Delphinus delphis) 76
4.2.13.1 Status and Management 76
4.2.13.2 Geographic Range and Distribution 77
4.2.13.3 Population and Abundance 77
4.2.14 Short-finned Pilot Whale (Globicephala macrorhynchus) 77
4.2.14.1 Status and Management 77
4.2.14.2 Geographic Range and Distribution 78
4.2.14.3 Population and Abundance 78
4.2.15 Sperm Whale (Physeter macrocephalus) 78
4.2.15.1 Status and Management 78
4.2.15.2 Geographic Range and Distribution 78
4.2.15.3 Population and Abundance 79
4.2.16 Striped Dolphin (Stenella coeruleoalba) 79
4.2.16.1 Status and Management 79
4.2.16.2 Geographic Range and Distribution 79
4.2.16.3 Population and Abundance 80
4.3 PINNIPEDS 80
4.3.1 California Sea Lion (Zalophus californianus) 80
4.3.1.1 Status and Management 80
4.3.1.2 Geographic Range and Distribution 80
4.3.1.3 Population and Abundance 82
4.3.2 Guadalupe Fur Seal (Arctocephalus townsendi) 83
4.3.2.1 Status and Management 83
4.3.2.2 Geographic Range and Distribution 83
4.3.2.3 Population and Abundance 84
4.3.3 Harbor Seal (Phoca vitulina) 84
4.3.3.1 Status and Management 84
4.3.3.2 Geographic Range and Distribution 84
4.3.3.3 Population and Abundance 86
4.3.4 Northern Elephant Seal (Mirounga angustirostris) 87
4.3.4.1 Status and Management 87
4.3.4.2 Geographic Range and Distribution 87
4.3.4.3 Population and Abundance 89

4.3.5 Northern Fur Seal (Callorhinus ursinus)....89
4.3.5.1 Status and Management....89
4.3.5.2 Geographic Range and Distribution....89
4.3.5.3 Population and Abundance....91
4.3.6 Steller Sea Lion (Eumetopias jubatus)....91
4.3.6.1 Status and Management....91
4.3.6.2 Geographic Range and Distribution....92
4.3.6.3 Population and Abundance....95

5 TYPE OF INCIDENTAL TAKING AUTHORIZATION REQUESTED....96

5.1 INCIDENTAL TAKE REQUEST FROM ACOUSTIC AND EXPLOSIVE SOURCES....97
5.1.1 Incidental Take Request from Acoustic and Explosive Sources for Training Activities....98
5.1.2 Incidental Take Request from Acoustic and Explosive Sources for Testing Activities....101
5.2 VESSEL STRIKES....104

6 TAKE ESTIMATES FOR MARINE MAMMALS....106

6.1 ESTIMATED TAKE OF MARINE MAMMALS BY ACOUSTIC AND EXPLOSIVE SOURCES....106
6.2 CONCEPTUAL FRAMEWORK FOR ASSESSING EFFECTS FROM SOUND-PRODUCING ACTIVITIES....106
6.3 HEARING AND VOCALIZATION....109
6.4 ACOUSTIC STRESSORS....113
6.4.1 Background....113
6.4.1.1 Injury....113
6.4.1.2 Hearing Loss....117
6.4.1.3 Physiological Stress....120
6.4.1.4 Masking....123
6.4.1.5 Behavioral Reactions....128
6.4.1.6 Stranding....141
6.4.1.7 Long-Term Consequences....143
6.4.2 Impacts from Sonar and Other Transducers....147
6.4.2.1 Methods for Analyzing Impacts from Sonars and Other Transducers....147
6.4.2.2 Impact Ranges for Sonar and Other Transducers....158
6.4.2.3 Impacts from Sonar and Other Transducer Stressors Under the Proposed Action....167
6.5 EXPLOSIVE STRESSORS....234
6.5.1 Background....234
6.5.1.1 Injury....234
6.5.1.2 Hearing Loss....237
6.5.1.3 Physiological Stress....238
6.5.1.4 Masking....239
6.5.1.5 Behavioral Reactions....239
6.5.1.6 Stranding....244
6.5.1.7 Long-Term Consequences....245
6.5.2 Impacts from Explosives....245
6.5.2.1 Methods for Analyzing Impacts from Explosives....246
6.5.2.2 Impact Ranges for Explosives....251
6.5.2.3 Impacts from Explosives Stressors Under the Proposed Action....264
6.6 VESSEL STRIKE ANALYSIS....302

7 ANTICIPATED IMPACT OF THE ACTIVITY....307

7.1 LONG-TERM CONSEQUENCES TO SPECIES AND STOCKS....307
7.2 THE CONTEXT OF BEHAVIORAL DISRUPTION, TTS, AND PTS – BIOLOGICAL SIGNIFICANCE TO POPULATIONS....311

8 ANTICIPATED IMPACTS ON SUBSISTENCE USES 313

9 ANTICIPATED IMPACTS ON HABITAT 314

10 ANTICIPATED EFFECTS OF HABITAT IMPACTS ON MARINE MAMMALS 319

11 MITIGATION MEASURES 320

11.1 PROCEDURAL MITIGATION 320
11.1.1 Acoustic Stressors 322
11.1.2 Explosive Stressors 324
11.1.3 Physical Disturbance and Strike Stressors 331
11.2 MITIGATION AREAS 336
11.3 MITIGATION SUMMARY 345

12 ARCTIC PLAN OF COOPERATION 348

13 MONITORING AND REPORTING 349

13.1 MONITORING, RESEARCH, AND REPORTING INITIATIVES 349
13.2 INTEGRATED COMPREHENSIVE MONITORING PROGRAM 350
13.3 STRATEGIC PLANNING PROCESS 351
13.4 MONITORING PROGRESS IN NWTT 353
13.5 PROPOSED NAVY-FUNDED MONITORING 354
13.6 REPORTING 354

14 SUGGESTED MEANS OF COORDINATION 356

14.1 OVERVIEW 356
14.2 NAVY RESEARCH AND DEVELOPMENT 357
14.2.1 Navy Funded Research 357
14.2.2 Other Government Funded Research 357

15 LIST OF PREPARERS 358

16 BIBLIOGRAPHY 360

LIST OF TABLES

Table 1-1: Sonar and Other Transducers Quantitatively Analyzed 11
Table 1-2: Explosive Sources Quantitatively Analyzed that Could Be Used Underwater or at the Water Surface in the Study Area 13
Table 1-3: Proposed Training Activities that may Result in MMPA Takes of Marine Mammals Within the NWTT Study Area 15
Table 1-4: Proposed Testing Activities that may Result in MMPA Takes of Marine Mammals Within the NWTT Study Area 18
Table 1-5: Acoustic Source Class Bins Analyzed and Numbers Used during Training Activities 23
Table 1-6: Acoustic Source Class Bins Analyzed and Numbers Used during Testing Activities 24
Table 1-7: Explosive Source Class Bins Analyzed and Numbers Used during Training Activities 26
Table 1-8: Explosive Source Class Bins Analyzed and Numbers Used during Testing Activities 26
Table 1-9: Mitigation Categories 28
Table 3-1: Marine Mammals Occurrence Within the NWTT Study Area 41
Table 4-1: Abundance and Trend of Eastern U.S. Stock of Steller Sea Lions in U.S. Waters in 2015 95
Table 5-1: Summary of Annual and 7-Year Take Request from Acoustic and Explosive Sources for NWTT Training and Testing Activities 98
Table 5-2: Species-Specific Take Requests from Modeling Estimates of Acoustic and Explosive Sound Source Effects for All Training Activities 99
Table 5-3: Species-Specific Take Requests from Modeling Estimates of Acoustic and Explosive Sound Source Effects for All Testing Activities 101
Table 5-4: Poisson Probability of Striking "X" Number of Whales When Expecting 1.36 Total Strikes over a 7-year Period in the NWTT Study Area 105
Table 6-1: Species Within Marine Mammal Hearing Groups Likely Found in the Study Area 110
Table 6-2: Cutoff Distances for Moderate Source Level, Single Platform Training and Testing Events and for All Other Events with Multiple Platforms or Sonar with Source Levels at or Exceeding 215 dB re 1 µPa @ 1 m 155
Table 6-3: Range to Permanent Threshold Shift for Five Representative Sonar Systems 159
Table 6-4: Ranges to Temporary Threshold Shift for Sonar Bin HF4 over a Representative Range of Environments Within the Study Area 160
Table 6-5: Ranges to Temporary Threshold Shift for Sonar Bin LF4 over a Representative Range of Environments Within the Study Area 160
Table 6-6: Ranges to Temporary Threshold Shift for Sonar Bin MF1 over a Representative Range of Environments Within the Study Area 161
Table 6-7: Ranges to Temporary Threshold Shift for Sonar Bin MF4 over a Representative Range of Environments Within the Study Area 161
Table 6-8: Ranges to Temporary Threshold Shift for Sonar Bin MF5 over a Representative Range of Environments Within the Study Area 162
Table 6-9: Ranges to a Potentially Significant Behavioral Response for Sonar Bin HF4 over a Representative Range of Environments within the Study Area 163
Table 6-10: Ranges to a Potentially Significant Behavioral Response for Sonar Bin LF4 over a Representative Range of Environments Within the Study Area 164
Table 6-11: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF1 over a Representative Range of Environments within the Study Area 165
Table 6-12: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF4 over a Representative Range of Environments within the Study Area 166
Table 6-13: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF5 over a Representative Range of Environments within the Study Area 167
Table 6-14: Estimated Impacts on Individual Blue Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action 175
Table 6-15: Estimated Impacts on Individual Fin Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action 177

TABLE 6-16: ESTIMATED IMPACTS ON INDIVIDUAL SEI WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 179
TABLE 6-17: ESTIMATED IMPACTS ON INDIVIDUAL MINKE WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 181
TABLE 6-18: ESTIMATED IMPACTS ON INDIVIDUAL HUMPBACK WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 183
TABLE 6-19: ESTIMATED IMPACTS ON INDIVIDUAL GRAY WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 185
TABLE 6-20: ESTIMATED IMPACTS ON INDIVIDUAL COMMON BOTTLENOSE DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....190
TABLE 6-21: ESTIMATED IMPACTS ON INDIVIDUAL KILLER WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 192
TABLE 6-22: ESTIMATED IMPACTS ON INDIVIDUAL NORTHERN RIGHT WHALE DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....194
TABLE 6-23: ESTIMATED IMPACTS ON INDIVIDUAL PACIFIC WHITE-SIDED DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....196
TABLE 6-24: ESTIMATED IMPACTS ON INDIVIDUAL RISSO'S DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 198
TABLE 6-25: ESTIMATED IMPACTS ON INDIVIDUAL SHORT-BEAKED COMMON DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....200
TABLE 6-26: ESTIMATED IMPACTS ON INDIVIDUAL SHORT-FINNED PILOT WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....202
TABLE 6-27: ESTIMATED IMPACTS ON INDIVIDUAL STRIPED DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 204
TABLE 6-28: ESTIMATED IMPACTS ON INDIVIDUAL DWARF SPERM WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM EXPLOSIONS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....206
TABLE 6-29: ESTIMATED IMPACTS ON INDIVIDUAL PYGMY SPERM WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM EXPLOSIONS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....207
TABLE 6-30: ESTIMATED IMPACTS ON INDIVIDUAL DALL'S PORPOISE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 210
TABLE 6-31: ESTIMATED IMPACTS ON INDIVIDUAL HARBOR PORPOISE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 213
TABLE 6-32: ESTIMATED IMPACTS ON INDIVIDUAL SPERM WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 215
TABLE 6-33: ESTIMATED IMPACTS ON INDIVIDUAL BAIRD'S BEAKED WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....218
TABLE 6-34: ESTIMATED IMPACTS ON INDIVIDUAL CUVIER'S BEAKED WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....219
TABLE 6-35: ESTIMATED IMPACTS ON INDIVIDUAL MESOPLODON SPP. (SMALL BEAKED WHALE GUILD) STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 220
TABLE 6-36: ESTIMATED IMPACTS ON INDIVIDUAL CALIFORNIA SEA LION STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION. 224
TABLE 6-37: ESTIMATED IMPACTS ON INDIVIDUAL STELLER SEA LION STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 226
TABLE 6-38: ESTIMATED IMPACTS ON INDIVIDUAL GUADALUPE FUR SEAL STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 228
TABLE 6-39: ESTIMATED IMPACTS ON INDIVIDUAL NORTHERN FUR SEAL STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION 230
TABLE 6-40: ESTIMATED IMPACTS ON INDIVIDUAL HARBOR SEAL STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION. 232
TABLE 6-41: ESTIMATED IMPACTS ON INDIVIDUAL NORTHERN ELEPHANT SEAL STOCKS WITHIN THE STUDY AREA PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION.....234

TABLE 6-42: CRITERIA TO QUANTITATIVELY ASSESS NON-AUDITORY INJURY DUE TO UNDERWATER EXPLOSIONS 247
TABLE 6-43: NAVY PHASE III WEIGHTED SOUND EXPOSURE LEVEL BEHAVIORAL RESPONSE, TEMPORARY THRESHOLD AND PERMANENT ONSET THRESHOLDS AND UNWEIGHTED PEAK SOUND PRESSURE LEVEL TEMPORARY THRESHOLD AND PERMANENT ONSET THRESHOLDS FOR UNDERWATER EXPLOSIVE SOUNDS.....250
TABLE 6-44: RANGES[1] TO NON-AUDITORY INJURY (IN METERS) FOR ALL MARINE MAMMAL HEARING GROUPS 252
TABLE 6-45: RANGES[1] TO MORTALITY (IN METERS) FOR ALL MARINE MAMMAL HEARING GROUPS AS A FUNCTION OF ANIMAL MASS 254
TABLE 6-46: SEL-BASED RANGES TO ONSET PTS, ONSET TTS, AND BEHAVIORAL REACTION (IN METERS) FOR HIGH-FREQUENCY CETACEANS.....254
TABLE 6-47: PEAK PRESSURE-BASED RANGES TO ONSET PTS AND ONSET TTS (IN METERS) FOR HIGH-FREQUENCY CETACEANS.....256
TABLE 6-48: SEL-BASED RANGES TO ONSET PTS, ONSET TTS, AND BEHAVIORAL REACTION (IN METERS) FOR LOW-FREQUENCY CETACEANS.....257
TABLE 6-49: PEAK PRESSURE-BASED RANGES TO ONSET PTS AND ONSET TTS (IN METERS) FOR LOW-FREQUENCY CETACEANS.....258
TABLE 6-50: SEL-BASED RANGES TO ONSET PTS, ONSET TTS, AND BEHAVIORAL REACTION (IN METERS) FOR MID-FREQUENCY CETACEANS.....259
TABLE 6-51: PEAK PRESSURE-BASED RANGES TO ONSET PTS AND ONSET TTS (IN METERS) FOR MID-FREQUENCY CETACEANS 260
TABLE 6-52: SEL-BASED RANGES TO ONSET PTS, ONSET TTS, AND BEHAVIORAL REACTION (IN METERS) FOR OTARIIDS.....261
TABLE 6-53: PEAK PRESSURE-BASED RANGES TO ONSET PTS AND ONSET TTS (IN METERS) FOR OTARIIDS 262
TABLE 6-54: SEL-BASED RANGES TO ONSET PTS, ONSET TTS, AND BEHAVIORAL REACTION (IN METERS) FOR PHOCIDS 263
TABLE 6-55: PEAK PRESSURE-BASED RANGES TO ONSET PTS AND ONSET TTS (IN METERS) FOR PHOCIDS.....264
TABLE 6-56: ESTIMATED IMPACTS ON INDIVIDUAL BLUE WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 268
TABLE 6-57: ESTIMATED IMPACTS ON INDIVIDUAL FIN WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 270
TABLE 6-58: ESTIMATED IMPACTS ON INDIVIDUAL SEI WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 271
TABLE 6-59: ESTIMATED IMPACTS ON INDIVIDUAL MINKE WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 273
TABLE 6-60: ESTIMATED IMPACTS ON INDIVIDUAL HUMPBACK WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 274
TABLE 6-61: ESTIMATED IMPACTS ON INDIVIDUAL GRAY WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 276
TABLE 6-62: ESTIMATED IMPACTS ON INDIVIDUAL NORTHERN RIGHT WHALE DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION.....280
TABLE 6-63: ESTIMATED IMPACTS TO INDIVIDUAL PACIFIC WHITE-SIDED DOLPHIN STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION.....282
TABLE 6-64: ESTIMATED IMPACTS ON INDIVIDUAL PYGMY SPERM WHALE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION. 286
TABLE 6-65: ESTIMATED IMPACTS ON INDIVIDUAL DALL'S PORPOISE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 288
TABLE 6-66: ESTIMATED IMPACTS ON INDIVIDUAL HARBOR PORPOISE STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 291
TABLE 6-67: ESTIMATED IMPACTS ON INDIVIDUAL CALIFORNIA SEA LION STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 295
TABLE 6-68: ESTIMATED IMPACTS ON INDIVIDUAL STELLER SEA LION STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 297
TABLE 6-69: ESTIMATED IMPACTS ON INDIVIDUAL HARBOR SEAL STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION 300
TABLE 6-70: ESTIMATED IMPACTS ON INDIVIDUAL NORTHERN ELEPHANT SEAL STOCKS WITHIN THE STUDY AREA PER YEAR FROM TRAINING AND TESTING EXPLOSIONS USING THE MAXIMUM NUMBER OF EXPLOSIONS UNDER THE PROPOSED ACTION.....302
TABLE 6-71: POISSON PROBABILITY OF STRIKING "X" NUMBER OF WHALES WHEN EXPECTING 1.36 TOTAL STRIKES OVER A 7-YEAR PERIOD IN THE NWTT STUDY AREA 305
TABLE 11-1: PROCEDURAL MITIGATION FOR ENVIRONMENTAL AWARENESS AND EDUCATION 321

TABLE 11-2: PROCEDURAL MITIGATION FOR ACTIVE SONAR....322
TABLE 11-3: PROCEDURAL MITIGATION FOR WEAPONS FIRING NOISE....323
TABLE 11-4: PROCEDURAL MITIGATION FOR EXPLOSIVE SONOBUOYS....324
TABLE 11-5: PROCEDURAL MITIGATION FOR EXPLOSIVE TORPEDOES....325
TABLE 11-6: PROCEDURAL MITIGATION FOR EXPLOSIVE MEDIUM-CALIBER AND LARGE-CALIBER PROJECTILES....326
TABLE 11-7: PROCEDURAL MITIGATION FOR EXPLOSIVE MISSILES....327
TABLE 11-8: PROCEDURAL MITIGATION FOR EXPLOSIVE BOMBS....328
TABLE 11-9: PROCEDURAL MITIGATION FOR EXPLOSIVE MINE COUNTERMEASURE AND NEUTRALIZATION ACTIVITIES....329
TABLE 11-10: PROCEDURAL MITIGATION FOR EXPLOSIVE MINE NEUTRALIZATION ACTIVITIES LNVOLVING NAVY DIVERS....330
TABLE 11-11: PROCEDURAL MITIGATION FOR VESSEL MOVEMENT....332
TABLE 11-12: PROCEDURAL MITIGATION FOR TOWED IN-WATER DEVICES....332
TABLE 11-13: PROCEDURAL MITIGATION FOR SMALL-, MEDIUM-, AND LARGE-CALIBER NON-EXPLOSIVE PRACTICE MUNITIONS....334
TABLE 11-14: PROCEDURAL MITIGATION FOR NON-EXPLOSIVE MISSILES....335
TABLE 11-15: PROCEDURAL MITIGATION FOR NON-EXPLOSIVE BOMBS AND MINE SHAPES....336
TABLE 11-16: MITIGATION AREAS IN THE NWTT STUDY AREA....342
TABLE 11-17: SUMMARY OF PROCEDURAL MITIGATION FOR MARINE MAMMALS....345

LIST OF FIGURES

FIGURE 1-1: NORTHWEST TRAINING AND TESTING STUDY AREA....3
FIGURE 2-1: NORTHWEST TRAINING AND TESTING STUDY AREA....33
FIGURE 2-2: OFFSHORE AREA OF THE NORTHWEST TRAINING AND TESTING STUDY AREA....34
FIGURE 2-3: INLAND WATERS OF THE NORTHWEST TRAINING AND TESTING STUDY AREA....35
FIGURE 2-4: SOUTHEAST ALASKA ACOUSTIC MEASUREMENT FACILITY....39
FIGURE 4-1: BATHYMETRY OF THE OFFSHORE AREA....45
FIGURE 6-1. FLOW CHART OF THE EVALUATION PROCESS OF SOUND-PRODUCING ACTIVITIES....108
FIGURE 6-2: COMPOSITE AUDIOGRAMS FOR HEARING GROUPS LIKELY FOUND IN THE STUDY AREA....111
FIGURE 6-3: TWO HYPOTHETICAL THRESHOLD SHIFTS....118
FIGURE 6-4: ODONTOCETE CRITICAL RATIOS....125
FIGURE 6-5: CRITICAL RATIOS FOR DIFFERENT NOISE TYPES....126
FIGURE 6-6: NAVY AUDITORY WEIGHTING FUNCTIONS FOR ALL SPECIES GROUPS....149
FIGURE 6-7: TTS AND PTS EXPOSURE FUNCTIONS FOR SONAR AND OTHER TRANSDUCERS....150
FIGURE 6-8: BEHAVIORAL RESPONSE FUNCTION FOR ODONTOCETES....152
FIGURE 6-9: BEHAVIORAL RESPONSE FUNCTION FOR PINNIPEDS....153
FIGURE 6-10: BEHAVIORAL RESPONSE FUNCTION FOR MYSTICETES....153
FIGURE 6-11: BEHAVIORAL RESPONSE FUNCTION FOR BEAKED WHALES....154
FIGURE 6-12: RELATIVE LIKELIHOOD OF A RESPONSE BEING SIGNIFICANT BASED ON THE DURATION AND SEVERITY OF BEHAVIORAL REACTIONS....156
FIGURE 6-13: BLUE WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....174
FIGURE 6-14: FIN WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....176
FIGURE 6-15: SEI WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....178
FIGURE 6-16: MINKE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....180
FIGURE 6-17: HUMPBACK WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....182
FIGURE 6-18: GRAY WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....184

FIGURE 6-19: COMMON BOTTLENOSE DOLPHIN IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....189
FIGURE 6-20: KILLER WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....191
FIGURE 6-21: NORTHERN RIGHT WHALE DOLPHIN IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....193
FIGURE 6-22: PACIFIC WHITE-SIDED DOLPHIN IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....195
FIGURE 6-23: RISSO'S DOLPHIN IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....197
FIGURE 6-24: SHORT-BEAKED COMMON DOLPHIN IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....199
FIGURE 6-25: SHORT-FINNED PILOT WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....201
FIGURE 6-26: STRIPED DOLPHIN IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....203
FIGURE 6-27: DWARF SPERM WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....205
FIGURE 6-28: PYGMY SPERM WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....206
FIGURE 6-29: DALL'S PORPOISE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....209
FIGURE 6-30: HARBOR PORPOISE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....212
FIGURE 6-31: SPERM WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....214
FIGURE 6-32: BAIRD'S BEAKED WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....217
FIGURE 6-33: CUVIER'S BEAKED WHALE IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....218
FIGURE 6-34: MESOPLODON SPP. (SMALL BEAKED WHALE GUILD) IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....220
FIGURE 6-35: CALIFORNIA SEA LION IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....223
FIGURE 6-36: STELLER SEA LION IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....225
FIGURE 6-37: GUADALUPE FUR SEAL IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....227
FIGURE 6-38: NORTHERN FUR SEAL IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....229
FIGURE 6-39: HARBOR SEAL IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....231
FIGURE 6-40: NORTHERN ELEPHANT SEAL IMPACTS ESTIMATED PER YEAR FROM SONAR AND OTHER TRANSDUCERS USED DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....233
FIGURE 6-41: NAVY PHASE 3 WEIGHTING FUNCTIONS FOR ALL SPECIES GROUPS....248
FIGURE 6-42: NAVY PHASE III BEHAVIORAL, TTS AND PTS EXPOSURE FUNCTIONS FOR EXPLOSIVES....249
FIGURE 6-43: BLUE WHALE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TESTING UNDER THE PROPOSED ACTION....268
FIGURE 6-44: FIN WHALE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....269
FIGURE 6-45: SEI WHALE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TESTING UNDER THE PROPOSED ACTION....271

FIGURE 6-46: MINKE WHALE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TESTING UNDER THE PROPOSED ACTION....272
FIGURE 6-47: HUMPBACK WHALE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TESTING UNDER THE PROPOSED ACTION....274
FIGURE 6-48: GRAY WHALE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....276
FIGURE 6-49: NORTHERN RIGHT WHALE DOLPHIN IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....280
FIGURE 6-50: PACIFIC WHITE-SIDED DOLPHIN IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....281
FIGURE 6-51: PYGMY SPERM WHALES IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TESTING UNDER THE PROPOSED ACTION....285
FIGURE 6-52: DALL'S PORPOISE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....287
FIGURE 6-53: HARBOR PORPOISE IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....290
FIGURE 6-54: CALIFORNIA SEA LION IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....295
FIGURE 6-55: STELLER SEA LION IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TESTING UNDER THE PROPOSED ACTION....296
FIGURE 6-56: HARBOR SEAL IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....299
FIGURE 6-57: NORTHERN ELEPHANT SEAL IMPACTS ESTIMATED PER YEAR FROM THE MAXIMUM NUMBER OF EXPLOSIONS DURING TRAINING AND TESTING UNDER THE PROPOSED ACTION....302
FIGURE 11-1: ALL MITIGATION AREAS IN THE STUDY AREA....344

ACRONYMS AND ABBREVIATIONS

µPa	micropascal(s)
µPa^2-sec	micropascal squared second
AEP	Auditory Evoked Potential
A-S	Air-to-Surface
ASW	Anti-Submarine Warfare
ATCAA	Air Traffic Control Assigned Airspace
CFR	Code of Federal Regulations
dB	decibel(s)
dB re 1 µPa	decibels referenced to 1 micropascal
DPS	Distinct Population Segment
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EO	Executive Order
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act
FR	Federal Register
ft.	feet
GUNEX	Gunnery Exercise
Helo	helicopter
HF	High-Frequency
Hz	hertz
in.	inch(es)
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometers
lb.	pound(s)
LF	Low-Frequency
LOA	Letter of Authorization
m	meter(s)
MF	Mid-Frequency
mi.	mile(s)
MISSILEX	Missile Exercise
MMPA	Marine Mammal Protection Act
MOA	Military Operations Area
MPA	Maritime Patrol Aircraft
NAEMO	Navy Acoustic Effects Model
NAVBASE	Naval Base
Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act
NM	nautical mile(s)
NM^2	square nautical miles
NMFS	National Marine Fisheries Service
NWTT	Northwest Training and Testing
OEIS	Overseas Environmental Impact Statement
OPAREA	Operations Area
OPNAV 45	Chief of Naval Operations Energy and Environmental Readiness
Pa-s	Pascal seconds
PACNW	Pacific Northwest
PCAD	Population Consequences of Acoustic Disturbance
psi	pounds per square inch
PTS	Permanent Threshold Shift
re	relative to
rms	root mean square
S-S	Surface-to-Surface
SAR	Stock Assessment Report
SD	Swimmer Detection Sonar
SEAFAC	Southeast Alaska Acoustic Measurement Facility
SEIS	Supplemental Environmental Impact Statement
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SUA	Special Use Airspace
SUS	Signal Underwater Sound
TNT	trinitrotoluene
TORP	Torpedo
TORPEX	Torpedo Exercise
TRACKEX	Tracking Exercise
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
VHF	Very High-Frequency
W	Warning Area
yd.	yard(s)

This page intentionally left blank.

1 Description of Specified Activity

1.1 INTRODUCTION

This Request for Regulations and Letters of Authorization (LOAs) for the Incidental Taking of Marine Mammals has been prepared in accordance with the applicable regulations of the Marine Mammal Protection Act (MMPA), as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law 108–136), and further amended by the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Public Law 115–232). The request for LOAs is based on (1) the analysis of spatial and temporal distributions of protected marine mammals in the Study Area, (2) the review of proposed activities analyzed in the NWTT Draft Supplemental Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (2019b) that have the potential to incidentally take marine mammals, and (3) a technical risk assessment to determine the likelihood of effects from those activities.

The United States (U.S.) Department of the Navy (Navy) has prepared this request for two LOAs for the incidental taking (as defined in Chapter 5, Type of Incidental Taking Authorization Requested) of marine mammals during training and testing activities within the Northwest Training and Testing (NWTT) Study Area (Figure 1-1). The Navy is requesting a 7-year LOA for training activities and a 7-year LOA for testing activities, each proposed to be conducted from 2020 through 2027.

Under the MMPA of 1972, as amended (16 United States Code [U.S.C.] section 1371(a)(5)), the Secretary of Commerce shall allow, upon request, the incidental, but not intentional, taking of marine mammals if certain findings are made and regulations are issued after notice and opportunity for public comment. The Secretary must find that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. The regulations must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock(s), and requirements pertaining to the monitoring and reporting of such taking.

Pursuant to the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114 (*Environmental Impacts Abroad of Major Federal Actions*), the Navy is preparing a Supplement (the NWTT Draft Supplemental EIS/ OEIS) to the October 2015 Northwest Training and Testing EIS/ OEIS (U.S. Department of the Navy, In Preparation) (hereinafter referred to as the 2015 NWTT Final EIS/OEIS). These documents assess the potential environmental impacts associated with proposed training and testing activities to be conducted at sea. These proposed activities are generally a continuation of ongoing training and testing activities at sea as analyzed in the October 2015 *Final Northwest Training and Testing Activities Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2015b), hereinafter referred to as the 2015 NWTT Final EIS/OEIS, and are representative of the type of activities the military has conducted in the area for decades. These training and testing activities include the use of active sonar and other acoustic sources, as well as explosives and other types of training and testing at sea off the coast of Washington, Oregon, and northern California; in the Western Behm Canal, Alaska; and portions of waters of the Strait of Juan de Fuca and Puget Sound, including Navy pierside and harbor locations in Puget Sound.

A description of the Study Area (Figure 1-1) and the various components of that area are provided in Chapter 2 (Dates, Duration, and Specified Geographic Region). A description of the activities for which the Navy is requesting incidental take authorizations is provided in the following sections. This request

for two LOAs is based on the proposed activities in the Navy's Preferred Alternative (Alternative 1 in the NWTT Draft Supplemental EIS/OEIS, referred to in this document as the Proposed Action). The NWTT Draft Supplemental EIS/OEIS considers ongoing and future activities conducted at sea, updates training and testing requirements, incorporates new information from an updated acoustic effects model, updates marine mammal density data, and incorporates evolving and emergent best available applicable science.

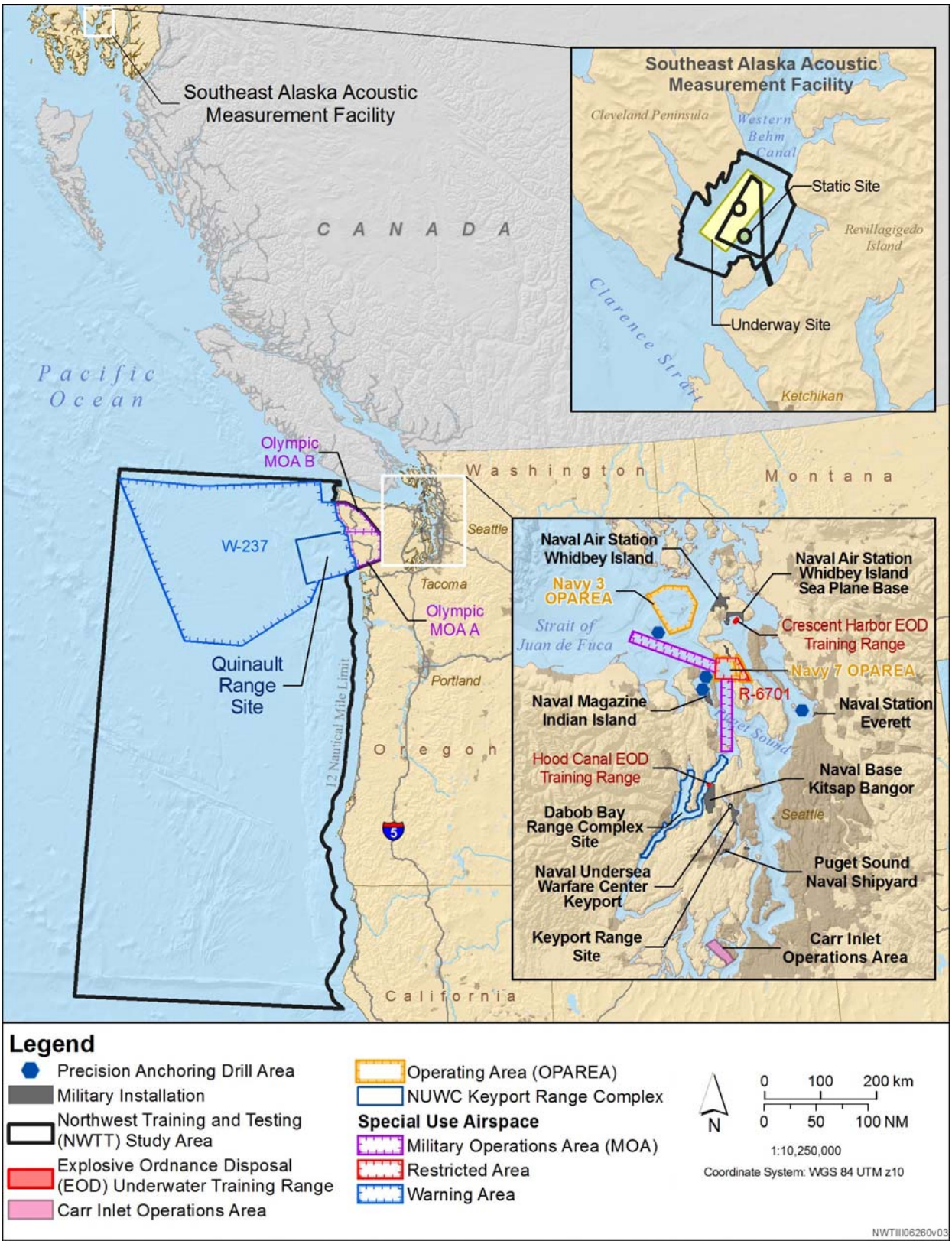


Figure 1-1: Northwest Training and Testing Study Area

This chapter describes those activities that are likely to result in Level B harassment, Level A harassment, or mortality under the MMPA. Of the Navy activities analyzed for the NWTT Draft Supplemental EIS/OEIS, the Navy has determined that only the use of sonar and other transducers and in-water detonations have the potential to affect marine mammals to a level that would constitute harassment under the MMPA. In addition to these potential impacts from specific activities, the Navy will also request takes from ship strikes that may occur during training or testing activities. These takes from ship strikes, however, are not specific to any particular training or testing activity.

1.2 BACKGROUND

The Navy's mission is to organize, train, equip, and maintain combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is mandated by federal law (Title 10 U.S.C. section 5062), which requires the readiness of the naval forces of the United States.[1] The Navy executes this responsibility by establishing and executing training programs, including at-sea training and exercises, and ensuring naval forces have access to the ranges, operating areas, and airspace needed to develop and maintain skills for conducting naval activities. Further, the Navy's testing activities ensure naval forces are equipped with well-maintained systems that take advantage of the latest technological advances. The Navy's research and acquisition community conducts military readiness activities that involve testing. The Navy tests ships, aircraft, weapons, combat systems, sensors, and related equipment; and conducts scientific research activities to achieve and maintain military readiness.

The Navy is preparing a Draft Supplemental EIS/OEIS to assess the potential environmental impacts associated with proposed Naval activities in the Study Area. The Navy is the lead agency for the NWTT Draft Supplemental EIS/OEIS, and National Marine Fisheries Service (NMFS) is a cooperating agency pursuant to 40 Code of Federal Regulations (CFR) sections 1501.6 and 1508.5.

In addition, in accordance with Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, the Navy is required to consult with NMFS for those actions it has determined may affect ESA-listed species or critical habitat under the jurisdiction of NMFS.

1.3 OVERVIEW OF TRAINING AND TESTING ACTIVITIES

1.3.1 PRIMARY MISSION AREAS

The Navy categorizes many of its training and testing activities into functional warfare areas called primary mission areas. The Navy's proposed activities for NWTT generally fall into the following six primary mission areas:

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

Most activities conducted in NWTT are categorized under one of these primary mission areas; activities that do not fall within one of these areas are listed as "other activities." Each warfare community

[1] Title 10, Section 5062 of the U.S.C. provides: "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of Naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with Integrated Joint Mobilization Plans, for the expansion of the peacetime components of the Navy to meet the needs of war."

(surface, subsurface, aviation, and expeditionary warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes most, but not all, of its testing activities under these primary mission areas. A description of the sonar, munitions, targets, systems, and other material used during training and testing activities within these primary mission areas is provided in the NWTT Draft Supplemental EIS/OEIS Appendix A (Navy Activities Descriptions).

The Navy describes and analyzes the effects of its activities within the NWTT Draft Supplemental EIS/OEIS. In its assessment, the Navy concluded that sonar and other transducers and underwater detonations were the stressors most likely to result in impacts on marine mammals that could rise to the level of harassment as defined under the MMPA. Therefore, this LOA application provides the Navy's assessment of potential effects from these stressors in terms of the various warfare mission areas in which they would be conducted. Those mission areas include the following:

- anti-submarine warfare (sonar and other transducers, underwater detonations),
- mine warfare (sonar and other transducers, underwater detonations),
- surface warfare (underwater detonations), and
- other (sonar and other transducers).

The Navy's activities in Air Warfare and Electronic Warfare do not involve sonar and other transducers, underwater detonations, or any other stressors that could result in harassment of marine mammals. The activities in these warfare areas are therefore not considered further in this request for LOAs but are analyzed fully in the Navy's NWTT Draft Supplemental EIS/OEIS.

1.3.1.1 Anti-Submarine Warfare

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

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

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

1.3.1.2 Expeditionary Warfare

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

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

1.3.1.3 Mine Warfare

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

Mine warfare training includes exercises in which ships, aircraft, submarines, underwater vehicles, unmanned vehicles, or marine mammal detection systems search for mine shapes. Personnel train to destroy or disable mines by attaching underwater explosives to or near the mine or using remotely operated vehicles to destroy the mine. Towed influence mine sweep systems mimic a particular ship's magnetic and acoustic signature, which would trigger a real mine, causing it to explode.

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

Most training and testing activities use mine shapes, or non-explosive practice mines, to accomplish the requirements of the activity. A small percentage of mine warfare activities require the use of high-explosive mines to evaluate and confirm the ability of the system or the crews conducting the training to neutralize a high-explosive mine under operational conditions. The majority of mine warfare systems are deployed by ships, helicopters, and unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

1.3.1.4 Surface Warfare

The mission of surface warfare is to obtain control of sea space from which naval forces may operate, which entails offensive action against surface targets while also defending against aggressive actions by enemy forces. In the conduct of surface warfare, aircraft use guns, air-launched cruise missiles, or other

precision-guided munitions; ships employ naval guns and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

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

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

1.3.1.5 Other Activities

Other training and testing is conducted in the Study Area that falls outside of the primary mission areas, but supports overall readiness. Surface ship crews conduct Maritime Security Operations events, including maritime security escorts for Navy vessels such as Fleet Ballistic Missile Submarines; Visit, Board, Search, and Seizure; Maritime Interdiction Operations; Force Protection; Anti-Piracy Operations, Acoustic Component Testing, Cold Water Support, and Hydrodynamic and maneuverability Testing. Anti-terrorism/Force-protection training will occur as small boat attacks against moored ships at one of the Navy's piers inside Puget Sound. Operator training is also necessary for the maintenance of ship and submarine sonar at piers and at-sea.

1.3.2 Overview of Navy Activities Within the Study Area

Training and testing activities and exercises covered in this request for LOAs are briefly described below, and in more detail within the NWTT Draft Supplemental EIS/OEIS.

The Navy has been conducting training and testing activities in the Study Area for decades, with some activities dating back to at least the early 1900s. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in warfighting doctrine and procedures, and changes in force structure (e.g., organization of ships, submarines, aircraft, weapons, and Sailors). Such developments influence the type, frequency, intensity, and location of required training and testing activities. The activities analyzed are largely a continuation of activities that have been ongoing and were analyzed previously in the 2015 NWTT Final EIS/OEIS as well as the 2010 Northwest Training Range Complex Final EIS/OEIS and 2010 NAVSEA NUWC Keyport Range Complex Extension Final EIS/OEIS. This request includes the analysis of those at-sea activities necessary to meet readiness requirements beyond 2020 and into the reasonably foreseeable future, includes any changes to those activities previously analyzed, and reflects the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements.

The activities that are part of the Proposed Action for this request for LOAs are described in Table 1-3 and Table 1-4, which include the activity name, a short description of the activity, the number of events proposed, typical duration, and locations. Appendix A (Navy Activities Descriptions) of the NWTT Draft Supplemental EIS/OEIS provides more detailed descriptions of the activities.

1.4 DESCRIPTION OF ACOUSTIC AND EXPLOSIVE STRESSORS

The Navy uses a variety of sensors, platforms, weapons, and other devices, including ones used to ensure the safety of Sailors, to meet its mission. Training and testing with these systems may introduce sound and energy into the environment. The proposed training and testing activities were evaluated to identify specific components that could act as stressors by having direct or indirect impacts on the environment. This analysis included identification of the spatial variation of the identified stressors. The following subsections describe the acoustic and explosive stressors for biological resources within the Study Area in detail. Each description contains a list of activities that may generate the stressor. A preliminary analysis identified the stressor/resource interactions that warrant further analysis in the LOA based on public comments received during scoping, previous NEPA analyses, and opinions of subject matter experts. Stressor/resource interactions that were determined to have negligible or no impacts (e.g., vessel noise, aircraft noise, weapons noise, and explosions in-air) were not carried forward for analysis in the request for LOAs, as is consistent with previous rule-making (National Oceanic and Atmospheric Administration, 2015a).

1.4.1 ACOUSTIC STRESSORS

This section describes the characteristics of sounds produced during naval training and testing and the relative magnitude and location of these sound-producing activities. This provides the basis for analysis of acoustic impacts on resources in Chapter 6 (Take Estimates for Marine Mammals). Explanations of the terminology and metrics used when describing sound in this LOA are in Appendix D (Acoustic and Explosive Concepts) of the NWTT Draft Supplemental EIS/OEIS.

Acoustic stressors include acoustic signals emitted into the water for a specific purpose, such as sonar, other transducers (devices that convert energy from one form to another—in this case, into sound waves), 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 hazardous characteristics (Section 1.4.2, Explosive Stressors). Characteristics of each of these sound sources are described in the following sections.

In order to better organize and facilitate the analysis of approximately 300 sources of underwater sound used by the Navy, including sonar and other transducers and explosives, a series of source classifications, or source bins, were developed. The source classification bins do not include the broadband noise produced incidental to vessel and aircraft transits and weapons firing. Noise from vessels, aircraft, and weapons firing are not carried forward for analysis in the LOA, for the reasons stated above.

The use of source classification bins provides the following benefits:

- Provides the ability for new sensors or munitions to be covered under existing authorizations, as long as those sources fall within the parameters of a “bin.”
- Improves efficiency of source utilization data collection and reporting requirements anticipated under the MMPA authorizations.
- Ensures a precautionary approach to all impact estimates, as all sources within a given class are modeled as the most impactful source (highest source level, longest duty cycle, or largest net explosive weight) within that bin.

- Allows analyses to be conducted in a more efficient manner, without any compromise of analytical results.
- Provides a framework to support the reallocation of source usage (hours/explosives) between different source bins, as long as the total numbers of takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training and testing requirements, which are linked to real world events.

1.4.1.1 Sonar and Other Transducers

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

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

Propagation of sound produced underwater is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors, including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher-frequency sounds propagate. The effects of these factors are explained in Appendix D (Acoustic and Explosive Concepts) of the NWTT Draft Supplemental EIS/OEIS. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the Study Area.

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

1.4.1.1.1 Anti-Submarine Warfare

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

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

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

1.4.1.1.2 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, or at targets of opportunity such as navigation buoys. Kingfisher mode on vessels is most likely to be used when transiting to and from port. Sound sources used for imaging could be used throughout the Study Area.

1.4.1.1.3 Navigation and Safety

Similar to commercial and private vessels, Military 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.

1.4.1.1.4 Communication

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

1.4.1.1.5 Classification of Sonar and Other Transducers

Sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose. As detailed below, classes are further sorted by bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used. Unless stated otherwise, a reference distance of 1 meter is used for sonar and other transducers.

- Frequency of the non-impulsive acoustic source

  - Low-frequency sources operate below 1 kHz
  - Mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
  - High-frequency sources operate above 10 kHz, up to and including 100 kHz
  - Very-high-frequency sources operate above 100 kHz but below 200 kHz

- Sound pressure level
  - Greater than 160 decibels (dB) referenced to 1 micropascal (dB re 1 µPa), but less than 180 dB re 1 µPa
  - Equal to 180 dB re 1 µPa and up to 200 dB re 1 µPa
  - Greater than 200 dB re 1 µPa

- Application in which the source would be used
  - Sources with similar functions that have similar characteristics, such as pulse length (duration of each pulse), beam pattern, and duty cycle

The bins used for classifying active sonars and transducers that are quantitatively analyzed in the Study Area are shown in Table 1-1. While general parameters or source characteristics are shown in the table, actual source parameters are classified.

Table 1-1: Sonar and Other Transducers Quantitatively Analyzed

Source Class Category	*Bin*	*Description*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF4	LF sources equal to 180 dB and up to 200 dB
	LF5	LF sources less than 180 dB
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-60)
	MF1K	Kingfisher mode associated with MF1 sonars
	MF2	Hull-mounted surface ship sonars (e.g., AN/SQS-56)
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Underwater sound signal devices (e.g., MK 84 SUS)
	MF9	Sources (equal to 180 dB and up to 200 dB) not otherwise binned
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	HF3	Other hull-mounted submarine sonars (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB) not otherwise binned
	HF6	Sources (equal to 180 dB and up to 200 dB) not otherwise binned
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)

Source Class Category	*Bin*	*Description*
	HF9	Weapon-emulating sonar source
Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 100 kHz but less than 200 kHz	VHF1	Active sources greater than 200 dB
	VHF2	Active sources with a source level less than 200 dB
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)
	ASW5[1]	MF sonobuoys with high duty cycles
Torpedoes (TORP): Active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK 46, MK 54, or Anti-Torpedo Torpedo)
	TORP2	Heavyweight torpedo (e.g., MK 48)
	TORP3	Heavyweight torpedo (e.g., MK 48)
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns
Acoustic Modems (M): Sources used to transmit data	M3	MF acoustic modems (greater than 190 dB)
Synthetic Aperture Sonars (SAS): Sonars used to form high-resolution images of the seafloor	SAS2	HF SAS systems
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB1	MF to HF mine countermeasure sonar
	BB2	HF to VHF mine countermeasure sonar

[1] Formerly ASW2 in Phase II.

1.4.2 EXPLOSIVE STRESSORS

This section describes the characteristics of explosions during naval training and testing. The activities analyzed in this Request for LOAs that use explosives are described in Appendix A (Navy Activities Descriptions) of the NWTT Draft Supplemental EIS/OEIS. Explanations of the terminology and metrics used when describing explosives are provided in Appendix D (Acoustic and Explosive Concepts) of the NWTT Draft Supplemental EIS/OEIS.

The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive in the warhead, the type of explosive material, the boundaries and characteristics of the propagation medium, and the detonation depth in water. The net explosive weight, which is the explosive power of a charge expressed as the equivalent weight of trinitrotoluene (TNT), accounts for the first two parameters. The effects of these factors are explained in Appendix D (Acoustic and Explosive Concepts) of the NWTT Draft Supplemental EIS/OEIS.

1.4.2.1 Explosions in Water

Explosive detonations during training and testing activities are associated with high-explosive munitions, including, but not limited to, bombs, missiles, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations during training and testing involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Detonations would typically occur in waters greater than 200 ft. in depth, and greater than 50 NM from shore, with the exception of mine countermeasure and neutralization testing proposed in the Offshore Area, and existing mine warfare areas in Inland Waters, (i.e., Crescent Harbor and Hood Canal Explosive Ordnance Disposal Training Ranges).

In order to better organize and facilitate the analysis of explosives used by the Navy during training and testing that could detonate in water or at the water surface, explosive classification bins were developed. The use of explosive classification bins provides the same benefits as described for acoustic source classification bins in Section 1.4.1 (Acoustic Stressors).

Explosives detonated in water are binned by net explosive weight. The bins of explosives that are proposed for use in the Study Area are shown in Table 1-2.

Propagation of explosive pressure waves in water is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity, which affect how the pressure waves are reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher-frequency components of explosive broadband noise can propagate. Appendix D (Acoustic and Explosive Concepts) of the NWTT Draft Supplemental EIS/OEIS explains the characteristics of explosive detonations and how the above factors affect the propagation of explosive energy in the water. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the Study Area.

Table 1-2: Explosive Sources Quantitatively Analyzed that Could Be Used Underwater or at the Water Surface in the Study Area

Bin	*Net Explosive Weight (lb.)*	*Example Explosive Source*	*Modeled Detonation Depths (ft.)*
E1	0.1–0.25	Medium-caliber projectiles	0.3, 60
E2	> 0.25–0.5	Medium-caliber projectiles	0.3
E3	> 0.5–2.5	Explosive Ordnance Disposal Mine Neutralization	33, 60
E4	> 2.5–5	Mine Countermeasure and Neutralization	197, 262, 295, 394
E5	> 5–10	Large-caliber projectile	0.3
E7	> 20–60	Mine Countermeasure and Neutralization	33, 98, 230, 295

E8	> 60–100	Lightweight torpedo	150
E10	> 250–500	1,000 lb. bomb	0.3
E11	> 500–650	Heavyweight torpedo	300, 656

Notes: Net Explosive Weight refers to the equivalent amount of TNT the actual weight of a munition may be larger due to other components; in. = inch(es), lb. = pound(s), ft. = feet

1.5 Proposed Action

The Navy proposes to continue conducting training and testing activities within the Study Area. The Navy has conducted training and testing activities in the Study Area for decades. Most recently, these activities were analyzed in the 2015 NWTT Final EIS/OEIS (U.S. Department of the Navy, 2015b). That document, its associated MMPA authorizations (National Oceanic and Atmospheric Administration, 2015b), and associated Biological Opinion (National Marine Fisheries Service, 2015) describe the training and testing activities currently conducted in the Study Area, which are similar to those proposed in this Request for LOAs. The Study Area is the same as described in the 2015 NWTT Final EIS/OEIS (Section 2.2, Primary Mission Areas) and current LOAs.

1.5.1 Training and Testing Activities

The training and testing activities that the Navy proposes to conduct in the Study Area, and that may result in MMPA takes of marine mammals, are described in Table 1-3 (training) and Table 1-4 (testing). The tables are organized according to primary mission areas and include the activity name, associated stressor(s), description and duration of the activity, sound source bin, the areas where the activity is conducted, the number of events per year, and the number of events over seven years. Not all sound sources are used with each activity. Under the "Annual # of Events" column, events show either a single number or a range of numbers to indicate the maximum number of times that activity could occur during any single year. The "7-Year # of Events" is the maximum number of times an activity would occur over the 7-year period of this application. More detailed activity descriptions can be found in the NWTT Draft Supplemental EIS/OEIS.

The Navy's Proposed Action reflects a representative year of training and testing to account for the natural fluctuation of training and testing cycles and deployment schedules that generally prevents the maximum level of activities from occurring year after year in any 7-year period.

For the purposes of this Request for LOAs, the Navy assumes that some unit-level training would be conducted using synthetic means (e.g., simulators). Additionally, the Proposed Action assumes that some unit-level active sonar training and some testing will be completed during other scheduled activities. By using a representative level of activity rather than a maximum level of activity in every year, the Proposed Action incorporates a degree of risk that the Navy would not have sufficient capacity in potential MMPA permits to conduct the necessary training and testing to meet future national emergencies.

1 **Table 1-3: Proposed Training Activities that may Result in MMPA Takes of Marine Mammals Within the NWTT Study Area**

Stressor Category	Activity	Description	Typical Duration	Source Bin	Location	Annual # of Events	7-Year # of Events
Anti-Submarine Warfare							
Acoustic; Explosive	Torpedo Exercise – Submarine (TORPEX – Sub)	Submarine crews search for, track, and detect submarines. Event would include one MK-48 torpedo used during this event.	8 hours	TORP2, E11	Offshore Area > 50 NM from land	0–2	5
Acoustic	Tracking Exercise – Helicopter (TRACKEX – Helo)	Helicopter crews search for, track, and detect submarines.	2–4 hours	MF4, MF5	Offshore Area > 12 NM from land	0–2	5
Acoustic	Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	Maritime patrol aircraft crews search for, track, and detect submarines.	2–8 hours	ASW2, ASW5, MF5	Offshore Area > 12 NM from land	373	2,611
Acoustic	Tracking Exercise – Ship (TRACKEX – Ship)	Surface ship crews search for, track, and detect submarines.	2–4 hours	ASW3, MF1, MF11	Offshore Area	62	434
Acoustic	Tracking Exercise – Submarine (TRACKEX – Sub)	Submarine crews search for, track, and detect submarines.	8 hours	HF1, MF3	Offshore Area	75–100	595
Mine Warfare							
Acoustic	Civilian Port Defense – Homeland Security Anti-Terrorism/ Force Protection Exercises	Maritime security personnel train to protect civilian ports and harbors against enemy efforts to interfere with access to those ports.	Multiple days	HF4, SAS2	Inland Waters	0–1	5

Stressor Category	Activity	Description	Typical Duration	Source Bin	Location	Annual # of Events	7-Year # of Events
Explosive	Mine Neutralization – Explosive Ordnance Disposal (EOD)	Personnel disable threat mines using explosive charges.	Up to 4 hours	E3	Crescent Harbor EOD Training Range, Hood Canal EOD Training Range	12	84
Surface Warfare							
Explosive	Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.	1 hour	E10	Offshore Area (W-237) > 50 NM from land	0–2 (counts only the explosive events)	5
Explosive	Gunnery Exercise (Surface-to-Surface) – Ship (GUNEX [S-S] – Ship)	Surface ship crews fire large- and medium-caliber guns at surface targets.	Up to 3 hours	E1, E2, E5	Offshore Area > 50 NM from land	90 (counts only the explosive events)	504
Explosive	Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing aircrews simulate firing precision-guided missiles, using captive air training missiles (CATMs) against surface targets. Some activities include firing a missile with a high-explosive (HE) warhead.	2 hours	E10	Offshore Area (W-237) > 50 NM from land	0–2	5

Stressor Category	Activity	Description	Typical Duration	Source Bin	Location	Annual # of Events	7-Year # of Events
Other Training							
Acoustic	Submarine Sonar Maintenance	Maintenance of submarine sonar and other system checks are conducted pierside or at sea.	Up to 1 hour	LF5, MF3	NBK Bangor, NBK Bremerton, and Offshore Area > 12 NM from land	26	182
Acoustic	Surface Ship Sonar Maintenance	Maintenance of surface ship sonar and other system checks are conducted pierside or at sea.	Up to 4 hours	MF1	NBK Bremerton, NS Everett, and Offshore Area > 12 NM from land	25	175
Acoustic	Unmanned Underwater Vehicle Training	Unmanned underwater vehicle certification involves training with unmanned platforms to ensure submarine crew proficiency. Tactical development involves training with various payloads for multiple purposes to ensure that the systems can be employed effectively in an operational environment.	Up to 24 hours	FLS2, M3	Inland Waters, Offshore Area	60	420

1 **Table 1-4: Proposed Testing Activities that may Result in MMPA Takes of Marine Mammals Within the NWTT Study Area**

Stressor Category	Activity	Description	Typical Duration	Source Bin	Location	Annual # of Events	7-Year # of Events
Naval Sea Systems Command Testing Activities							
Anti-Submarine Warfare							
Acoustic	Anti-Submarine Warfare Testing	Ships and their supporting platforms (rotary-wing aircraft and unmanned aerial systems) detect, localize, and prosecute submarines.	4–8 hours of active sonar use	ASW1, ASW2, ASW3, ASW5, MF1K, MF4, MF5, MF10, MF11, MF12, TORP1	Offshore Area	44	308
Acoustic	At-Sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment.	From 4 hours to 11 days	ASW3, HF1, HF5, M3, MF3, MF4, MF5	Offshore Area	5	33
				ASW3, HF5, MF4, MF5, TORP1	Inland Waters (DBRC)	5–7	39
Acoustic	Countermeasure Testing	Countermeasure testing involves the testing of systems that will detect, localize, and track incoming weapons, including marine vessel targets. Countermeasures may be systems to obscure the vessel's location or systems to rapidly detect, track, and counter incoming threats. Testing includes surface ship torpedo defense systems and marine vessel stopping payloads.	From 4 hours to 6 days	ASW3, ASW4	Offshore Area (QRS)	14	98
				ASW3, ASW4, HF8, MF1, TORP2	Inland Waters (DBRC, Keyport Range Site)	29	203
				ASW4	Western Behm Canal, AK	1	5
Acoustic	Pierside-Sonar Testing	Pierside testing to ensure systems are fully functional in a controlled pierside environment prior to at-sea test activities.	Up to 3 weeks	ASW3, HF3, MF1, MF2, MF3, MF9, MF10, MF12	Inland Waters (NS Everett, NBK Bangor, NBK Bremerton)	88–99	635

Stressor Category	Activity	Description	Typical Duration	Source Bin	Location	Annual # of Events	7-Year # of Events
Acoustic	Submarine Sonar Testing/ Maintenance	Pierside, moored, and underway testing of submarine systems occurs periodically following major maintenance periods and for routine maintenance.	Up to 3 weeks	HF6, MF9	Western Behm Canal, AK	1–2	10
Acoustic; Explosive	Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive and non-explosive torpedoes against artificial targets.	1–2 hours during daylight only	E8, E11, ASW3, HF1, HF6, MF1, MF3, MF4, MF5, MF6, TORP1, TORP2	Offshore Area > 50 NM from land	4	28
Acoustic	Torpedo (Non-explosive) Testing	Air, surface, or submarine crews employ non-explosive torpedoes against targets, submarines, or surface vessels.	Up to 2 weeks	ASW3, ASW4, HF1, HF5, HF6, MF1, MF3, MF4, MF5, MF6, MF9, MF10, TORP1, TORP2	Offshore Area	22	154
				HF6, LF4, TORP1, TORP2, TORP3	Inland Waters (DBRC)	61	427
Mine Warfare							
Acoustic; Explosive	Mine Countermeasure and Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines and mine-like objects.	1–10 days	E4, E7, HF4	Offshore Area	3	15
				HF4	Inland Waters	3	13
Acoustic	Mine Detection and Classification Testing	Air, surface, and subsurface vessels and systems detect and classify mines and mine-like objects. Vessels also assess their potential susceptibility to mines and mine-like objects.	Up to 24 days	BB1, BB2, HF4, LF4	Offshore Area (QRS)	1	7
					Inland Waters (DBRC, Keyport Range Site)	44	294

Stressor Category	Activity	Description	Typical Duration	Source Bin	Location	Annual # of Events	7-Year # of Events
Unmanned Systems							
Acoustic	Unmanned Underwater Vehicle Testing	Testing involves the production or upgrade of unmanned underwater vehicles. This may include testing of mission capabilities (e.g., mine detection), evaluating the basic functions of individual platforms, or conducting complex events with multiple vehicles.	Typically 1–2 days, up to multiple months	FLS2, HF5, TORP1, VHF1	Offshore Area (QRS)	38–39	269
				DS3, FLS2, HF5, HF9, M3, SAS2, VHF1, TORP1	Inland Waters (DBRC, Keyport Range Site, Carr Inlet)	371–379	2,615
Vessel Evaluation							
Acoustic	Undersea Warfare Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance, weapons engagement, and communications systems. This tests ships' ability to detect, track, and engage undersea targets.	Up to 10 days	ASW3, ASW4, HF4, MF1, MF4, MF5, MF6, MF9, TORP1, TORP2	Offshore Area	1–12	27
Other Testing							
Acoustic	Acoustic and Oceanographic Research	Research using active transmissions from sources deployed from ships, aircraft, and unmanned underwater vehicles. Research sources can be used as proxies for current and future Navy systems.	Up to 14 days	LF4, MF9	Offshore Area (QRS)	1	7
					Inland Waters (DBRC, Keyport Range Site)	3	21
Acoustic	Acoustic Component Testing	Various surface vessels, moored equipment, and materials are tested to evaluate performance in the marine environment.	1 day to multiple months	HF3, HF6, LF5, MF9	Western Behm Canal, AK	13–18	99
Acoustic	Cold Water Support	Fleet training for divers in a cold water environment, and other diver training related to Navy divers supporting range/test site operations and maintenance.	8 hours	HF6	Inland Waters (Keyport Range Site, DBRC, Carr Inlet)	4	28

Stressor Category	Activity	Description	Typical Duration	Source Bin	Location	Annual # of Events	7-Year # of Events
					Western Behm Canal, AK	1	7
Acoustic	Post-Refit Sea Trial	Following periodic maintenance periods or repairs, sea trials are conducted to evaluate submarine propulsion, sonar systems, and other mechanical tests.	8 hours	HF9, M3, MF10	Inland Waters (DBRC)	30	210
Acoustic	Semi-Stationary Equipment Testing	Semi-stationary equipment (e.g., hydrophones) is deployed to determine functionality.	From 10 minutes to multiple days	HF6, HF9, LF4, MF9, VHF2	Inland Waters (DBRC, Keyport Range Site)	120	840
				HF6, HF9	Western Behm Canal, AK	2–3	12
Naval Air Systems Command Testing Activities							
Anti-Submarine Warfare							
Acoustic; Explosive	Tracking Test – Maritime Patrol Aircraft	The test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to specifications and meet operational requirements.	4–8 flight hours	E1, E3, ASW2, ASW5, MF5, MF6	Offshore Area	8	56

1.5.2 SUMMARY OF ACOUSTIC AND EXPLOSIVE SOURCES ANALYZED FOR TRAINING AND TESTING

Source bins and numbers associated with Navy training and testing in the Study Area that were analyzed in this Request for LOAs are provided in Table 1-5 for the training acoustic source classes and numbers, Table 1-6 for testing acoustic source classes and numbers, Table 1-7 for training explosive source classes and numbers, and Table 1-8 for testing explosive source classes and numbers.

Table 1-5: Acoustic Source Class Bins Analyzed and Numbers Used during Training Activities

Source Class Category	*Bin*	*Description*	*Unit*	*Annual*	*7-year Total*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF5	LF sources less than 180 dB	H	1	5
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)	H	164	1,148
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	70	490
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22 and AN/AQS-13)	H	0–1	1
	MF5	Active acoustic sonobuoys (e.g., DICASS)	C	918–926	6,443
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	16	112
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	48	336
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	H	0–65	269
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	C	350	2,450
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	86	602
	ASW5	MF sonobuoys with high duty cycles	H	50	350
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK 46, MK 54, or Anti-Torpedo Torpedo)	C	16	112
	TORP2	Heavyweight torpedo (e.g., MK 48)	C	0–2	5
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	240	1,680
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)	H	30	210
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	HF SAS systems	H	0–561	2,353

Notes: H= hours; C = count

Table 1-6: Acoustic Source Class Bins Analyzed and Numbers Used during Testing Activities

Source Class Category	*Bin*	*Description*	*Unit*	*Annual*	*7-year Total*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF4	LF sources equal to 180 dB and up to 200 dB	H	177	1,239
	LF5	LF sources less than 180 dB	H	0-18	23
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)	H	20–169	398
	MF1K	Kingfisher mode associated with MF1 sonars	H	48	336
	MF2	Hull-mounted surface ship sonars (e.g., AN/SQS-56)	H	32	224
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	34–36	239
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22 and AN/AQS-13)	H	53–74	418
	MF5	Active acoustic sonobuoys (e.g., DICASS)	C	308–689	2,862
	MF6	Active underwater sound signal devices (e.g., MK 84 SUS)	C	60–232	744
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	644–959	5,086
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	886	6,197
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	48	336
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	100	700
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	10	68
	HF3	Other hull-mounted submarine sonars (classified)	H	1–19	30
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	H	1,860–1,868	11,235
	HF5	Active sources (greater than 200 dB) not otherwise binned	H	352–400	2,608
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	1,705–1,865	12,377
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)	H	24	168
	HF9	Weapon emulating sonar source	H	257	1,772
Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 100 kHz but less than 200 kHz	VHF1	Very high frequency sources greater than 200 dB	H	320	2,240
	VHF2	Active sources with a frequency greater than 100 kHz, up to 200 kHz with a source level less than 200 dB	H	135	945

Table 1-6: Acoustic Source Class Bins Analyzed and Numbers Used during Testing Activities (continued)

Source Class Category	*Bin*	*Description*	*Unit*	*Annual*	*7-year Total*
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB	H	80	560
	ASW2	MF systems operating above 200 dB	C	240	1,680
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	487–1,015	4,091
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)	C	1,349–1,389	9,442
	ASW5	MF sonobuoys with high duty cycles	H	80	560
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK 46, MK 54, or Anti-Torpedo Torpedo)	C	298–360	2,258
	TORP2	Heavyweight torpedo (e.g., MK 48)	C	332–372	2,234
	TORP3	Heavyweight torpedo test (e.g., MK 48)	C	6	42
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	24	168
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)	H	1,088	7,616
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	HF SAS systems	H	1,312	9,184
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB1	MF to HF mine countermeasure sonar	H	48	336
	BB2	HF to VHF mine countermeasure sonar	H	48	336

Notes: H= hours; C = count

Table 1-7: Explosive Source Class Bins Analyzed and Numbers Used during Training Activities

Bin	*Net Explosive Weight (lb.)*	*Example Explosive Source*	*Modeled Detonation Depths (ft.)*	*Annual*	*7-year Total*
E1	0.1–0.25	Medium-caliber projectiles		60–120	672
E2	> 0.25–0.5	Medium-caliber projectiles		65–130	728
E3	> 0.5–2.5	Explosive Ordnance Disposal Mine Neutralization		6	42
E5	> 5–10	Large-caliber projectile		56–112	628
E10	> 250–500	1,000 lb. bomb		0–4	9

Notes: (1) net explosive weight refers to the equivalent amount of TNT. The actual weight of a munition may be larger due to other components. lb. = pound(s), ft. = feet

Table 1-8: Explosive Source Class Bins Analyzed and Numbers Used during Testing Activities

Bin	*Net Explosive Weight (lb.)*	*Example Explosive Source*	*Modeled Detonation Depths (ft.)*	*Annual*	*7-year Total*
E1	0.1–0.25	SUS buoy		8	56
E3	> 0.5–2.5	Explosive sonobuoy		72	504
E4	> 2.5–5	Mine Countermeasure and Neutralization		36	180
E7	> 20–60	Mine Countermeasure and Neutralization		5	25
E8	> 60–100	Lightweight torpedo		4	28
E11	> 500–650	Heavyweight torpedo		4	28

Notes: (1) net explosive weight refers to the equivalent amount of TNT. The actual weight of a munition may be larger due to other components.
lb. = pound(s), ft. = feet

1.5.3 VESSEL MOVEMENTS

Vessels used as part of the Proposed Action include ships, submarines, unmanned vessels, and boats ranging in size from small, 22 ft. rigid hull inflatable boats to aircraft carriers with lengths up to 1,092 ft.

Large ships greater than 60 ft. generally operate at speeds in the range of 10–15 knots for fuel conservation. Submarines generally operate at speeds in the range of 8–13 knots in transits and less than those speeds for certain tactical maneuvers. Small craft (for purposes of this discussion – less than 60 ft. in length) have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to temporarily operate outside of these parameters. For example, to produce the required relative wind speed over the flight deck, an aircraft carrier engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances, such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search,

and seizure training events or retrieval of a target when vessels will be dead in the water or moving slowly ahead to maintain steerage.

The number of military vessels used in the Study Area varies based on military training and testing requirements, deployment schedules, annual budgets, and other unpredictable factors. Many training and testing activities involve the use of vessels. These activities could be widely dispersed throughout the Study Area, but would be typically conducted near naval ports, piers, and range areas. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to two weeks. There is no seasonal differentiation in military vessel use. Large vessel movement primarily occurs with the majority of the traffic flowing between the installations and the Operating Areas (OPAREAS). Smaller support craft would be more concentrated in the coastal waters in the areas of naval installations, ports, and ranges.

The number of activities that include the use of vessels for training events is lower (approximately 10 percent) than the number for testing activities. Testing can occur jointly with a training event, in which case that testing activity could be conducted from a training vessel.

Additionally, a variety of smaller craft will be operated within the Study Area. Small craft types, sizes and speeds vary. During training and testing, speeds generally range from 10 to 14 knots; however, vessels can and will, on occasion, operate within the entire spectrum of their specific operational capabilities. In all cases, the vessels/craft will be operated in a safe manner consistent with the local conditions.

1.5.4 Standard Operating Procedures

For training and testing to be effective, units must be able to safely use their sensors and weapon systems as they are intended to be used in military missions and combat operations and to their optimum capabilities. While standard operating procedures are designed for the safety of personnel and equipment and to ensure the success of training and testing activities, their implementation often yields benefits to environmental, socioeconomic, public health and safety, and cultural resources.

Navy standard operating procedures have been developed and refined over years of experience and are broadcast via numerous naval instructions and manuals, including, but not limited to the following materials:

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

Because standard operating procedures are essential to safety and mission success, the Navy considers them to be part of the proposed activities under the Proposed Action and has included them in the analysis within this Request for LOAs. Standard operating procedures that are recognized as having a benefit to marine mammals during training and testing activities are noted below:

- Vessel safety
- Weapons Firing Procedures
- Target Deployment Safety
- Towed In-Water Device Safety

Standard operating procedures differ from mitigation measures because mitigation is designed specifically for the purpose of avoiding or reducing environmental impacts, whereas standard operating procedures are designed to provide for safety and mission success. Information on mitigation measures is provided in Chapter 11 (Mitigation Measures) of this Request for LOAs and is summarized below. Additional information on standard operating procedures is presented in Section 2.3.3 (Standard Operating Procedures) in the NWTT Draft Supplemental EIS/OEIS.

1.5.5 MITIGATION MEASURES

The Navy implements mitigation to avoid or reduce potential impacts from the Proposed Action on marine mammals during activities involving anti-submarine warfare, mine warfare, surface warfare, and other warfare mission areas. Mitigation measures for marine mammals are designed to effect the least practicable adverse impact on marine mammal species or stocks and their habitat, have a negligible impact on marine mammal species and stocks (as required under the MMPA), and ensure that the Proposed Action does not jeopardize the continued existence of endangered or threatened species (as required under the ESA). The Navy will implement mitigation for the training and testing activity categories, stressors, and geographic locations listed in Table 1-9 as part of the Proposed Action. See Chapter 11 (Mitigation Measures) for a complete presentation of the procedural mitigation and mitigation areas that will be implemented under the Proposed Action.

Table 1-9: Mitigation Categories

Chapter 11 (Mitigation Measures) Section	*Applicable Stressor, Activity, or Location*
Section 11.1 (Procedural Mitigation)	Environmental Awareness and Education
Section 11.1.1 (Acoustic Stressors)	Active Sonar Weapons Firing Noise
Section 11.1.2 (Explosive Stressors)	Explosive Sonobuoys Explosive Torpedoes Explosive Medium-Caliber and Large-Caliber Projectiles Explosive Missiles Explosive Bombs Explosive Mine Countermeasure and Neutralization Activities Explosive Mine Neutralization Activities Involving Navy Divers
Section 11.1.3 (Physical Disturbance and Strike Stressors)	Vessel Movement Towed In-Water Devices Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions Non-Explosive Missiles Non-Explosive Bombs and Mine Shapes

Table 1-9: Mitigation Categories (continued)

Chapter 11 (Mitigation Measures) Section	*Applicable Stressor, Activity, or Location*
Section 11.2 (Mitigation Areas)	Marine Species Coastal Mitigation Area (year-round) Olympic Coast National Marine Sanctuary Mitigation Area (year-round) Stonewall and Heceta Bank Humpback Whale Mitigation Area (May – November) Point St. George Humpback Whale Mitigation Area (July – November) Puget Sound and Strait of Juan de Fuca Mitigation Area (year-round) Northern Puget Sound Gray Whale Mitigation Area (March – May)

2 Dates, Duration, and Specified Geographic Region

This request is for those training and testing activities that would be conducted in the NWTT Study Area throughout the year from the end of 2020 through the end of 2027. The number of annual and 7-year occurrences of the different training and testing events can be found in the last columns of Table 1-3 and Table 1-4. Also indicated is the location where the activity will occur within the Study Area.

The Study Area is composed of established maritime operating and warning areas in the eastern North Pacific Ocean region, including areas of the Strait of Juan de Fuca, Puget Sound, and Western Behm Canal in southeastern Alaska. The Study Area includes air and water space within and outside Washington state waters, within Alaska state waters, and outside state waters of Oregon and Northern California. The eastern boundary of the Offshore Area is 12 NM off the coastline for most of the Study Area, including southern Washington, Oregon, and Northern California. The Offshore Area includes the ocean all the way to the coastline only along that part of the Washington coast that lies beneath the airspace of W-237 and the Olympic Military Operating Area (MOA) and the Washington coastline north of the Olympic MOA (Figure 2-1). The Study Area includes four existing range complexes and facilities: the Northwest Training Range Complex, the Keyport Range Complex, Carr Inlet Operations Area, and the Southeast Alaska Acoustic Measurement Facility (Western Behm Canal, Alaska). In addition to these range complexes, the Study Area also includes Navy pierside locations where sonar maintenance and testing occurs as part of overhaul, modernization, maintenance, and repair activities at Naval Base Kitsap, Bremerton; Naval Base Kitsap, Bangor; and Naval Station Everett.

A range complex is a designated set of specifically bounded geographic areas; it encompasses a water component (above and below the surface) and may encompass airspace and a land component where training and testing of military platforms, tactics, munitions, explosives, and EW systems occurs. Range complexes include established OPAREAs, Restricted Areas, and special use airspace (SUA), which may be further divided to provide better control of the area and events for safety reasons.

- **Airspace**
    - **Special Use Airspace**. Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.10). Types of special use airspace most commonly found in range complexes include the following:
        - **Restricted Areas**. Airspace within which the operation of aircraft is subject to restriction. Restricted areas are established to separate activities considered to be hazardous to other aircraft, such as artillery firing or aerial gunnery munitions. (Federal Aviation Administration Order 7400.2L, Chapter 23).
        - **Military Operations Areas**. Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain nonhazardous military activities from instrument flight rules traffic and to identify visual flight rules traffic where these activities are conducted.
        - **Warning Areas**. Areas of defined dimensions, extending from 3 NM outward from the coast of the United States, which serve to warn non-participating aircraft of activities that may be hazardous.

  - **Air Traffic Control Assigned Airspace**. Airspace of defined vertical/lateral limits, implemented by Letter of Agreement between the user and the concerned Air Route Traffic Control Center, and assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activity being conducted within the assigned airspace and other instrument flight rules traffic.

- **Sea and Undersea Space**
  - **Operating Area**. An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. OPAREAs may include danger zones and restricted areas.
  - **Danger Zones and Restricted Areas**. Danger zones and restricted areas are water areas defined by federal regulation for the purpose of prohibiting or limiting public access. Restricted areas generally provide security for government property and also provide protection to the public from the risks of damage or injury arising from the government's use of that area (33 CFR part 334).

This application for LOAs does not address any activity which cannot impact marine mammals such as use of airspace over land or shoreside activity incidental to at-sea training or testing.

Military activities in the Study Area occur (1) on the ocean surface, (2) beneath the ocean surface, and (3) in the air. To aid in the description of the ranges covered in the 2015 NWTT Final EIS/OEIS, the ranges are divided into three distinct geographic and functional subdivisions. All of the training and testing activities proposed in this application would occur in one or more of these three range subdivisions:

- The Offshore Area
- The Inland Waters
- Western Behm Canal, Alaska

2.1 OFFSHORE AREA

The Offshore Area of the Study Area includes air, surface, and subsurface OPAREAs extending generally west from the coastline of Washington, Oregon, and Northern California for a distance of approximately 250 NM into international waters. The eastern boundary of the Offshore Area is 12 NM off the coastline for most of the Study Area, including southern Washington, Oregon, and Northern California. The Offshore Area includes the ocean all the way to the coastline only along that part of the Washington coast that lies beneath the airspace of W-237 and the Olympic MOA and the Washington coastline north of the Olympic MOA. The components of the Offshore Area are described below and depicted in Figure 2-2.

2.1.1 AIRSPACE

The SUA in the Offshore Area is comprised of Warning Area 237 (W-237), which extends westward off the coast of Northern Washington State and is divided into nine sub-areas (A-H, and J). The eastern boundary of W-237 lies 3 NM off the coast of Washington. The floor of W-237 extends to the ocean surface, and the ceiling of the airspace varies between 27,000 ft. in areas E, H, and J; 50,000 ft. in areas A and B; and unlimited in areas C, D, F, and G, with a total area of 25,331 square nautical miles (NM^2). The Olympic MOA overlays both land (the Olympic Peninsula) and sea (extending to 3 NM off the coast of Washington into the Pacific Ocean). The MOA lower limit is 6,000 ft. above mean sea level but not below 1,200 ft. above ground level, and the upper limit is up to, but not including, 18,000 ft., with total

area coverage of 1,614 NM^2. Above the Olympic MOA is the Olympic Air Traffic Control Assigned Airspace (ATCAA), which has a floor coinciding with the Olympic MOA ceiling. The ATCAA has an upper limit of 35,000 ft. For this application, the Olympic MOA and the Olympic ATCAA are components of the Offshore Area; all references to Olympic MOA and Olympic ATCAA here will be only to the segments which overlie the water west of the coast of Washington.

2.1.2 SEA AND UNDERSEA SPACE

The Offshore Area includes sea and undersea space approximately 510 NM in length from the northern boundary at the mouth of the Strait of Juan de Fuca to the southern boundary at 40 degrees (°) north (N) latitude, and 250 NM from the coastline to the western boundary at 130° west (W) longitude. Total surface area of the Pacific Northwest (PACNW) OPAREA is 121,600 NM^2. While the PACNW OPAREA extends to the shoreline throughout its length, the Study Area excludes that portion from the coastline of southern Washington (south of the Olympic MOA), Oregon, and Northern California out to 12 NM at sea.

Commander Submarine Force, U.S. Pacific Fleet Pearl Harbor uses this water space as a function of the safe operation of U.S. submarines. While the sea space is ample for all levels of Navy training, no infrastructure is in place to support training. For example, there are no dedicated training frequencies, no permanent instrumentation, no meteorological and oceanographic operations system, and no established target systems. In this region of the Pacific Ocean, storms and high sea states can create challenges to surface ship training between October and April. In addition, strong undersea currents in the Pacific Northwest make it difficult to place bottom-mounted instrumentation such as hydrophones.

Within the defined boundaries of the PACNW OPAREA lies the Quinault Range Site (see Figure 2-2). The Quinault Range Site coincides with the boundaries of W-237A, and also includes a surf zone component. The surf zone component extends north to south 5 NM along the eastern boundary of W-237A, extends approximately 3 NM to shore along the mean lower low water line, and encompasses 1 mile (mi.) (1.6 kilometers [km]) of shoreline at Pacific Beach, Washington. Surf-zone activities would be conducted from an area on the shore and seaward.

2.2 INLAND WATERS

The Inland Waters includes air, sea, and undersea space inland of the coastline, from buoy "J" at 48° 29.6' N, 125° W, eastward to include all U.S. waters of the Strait of Juan de Fuca and the Puget Sound. None of this area extends into Oregon or California. Within the Inland Waters are specific geographic components in which training and testing occur. The Inland Waters and its component areas are described below and depicted in Figure 2-3.

2.2.1 AIRSPACE

The special use airspace in the Inland Waters is depicted in Figure 2-3 and described below:

- Restricted Area 6701 (R-6701, Admiralty Bay) is a Restricted Area over Admiralty Bay, Washington with a lower limit at the ocean surface and an upper limit of 5,000 ft. This airspace covers a total area of 22 NM^2.
- Chinook A and B MOAs are 56 NM^2 of airspace south and west of Admiralty Bay. The Chinook MOAs extend from 300 ft. to 5,000 ft. above the ocean surface.

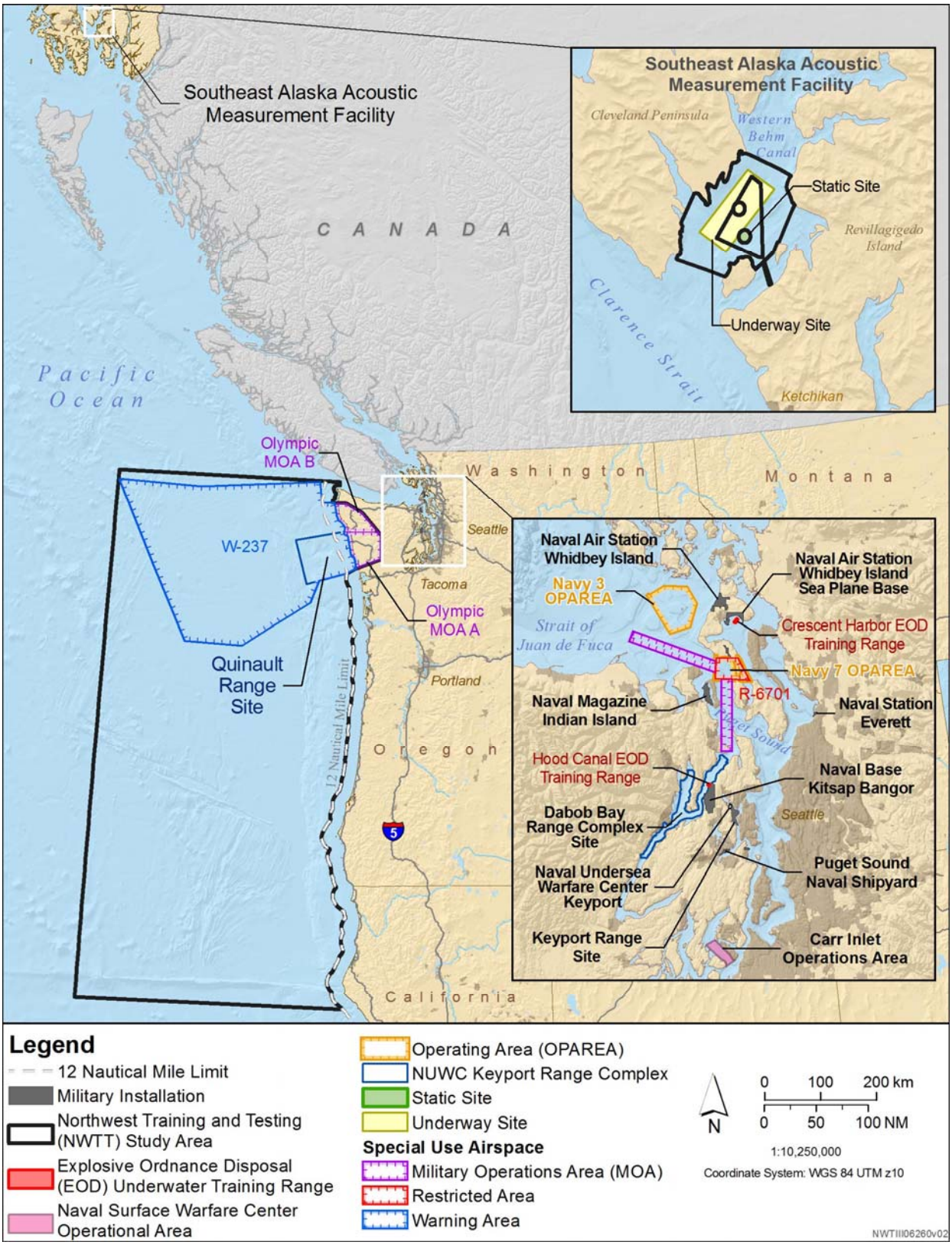


Figure 2-1: Northwest Training and Testing Study Area

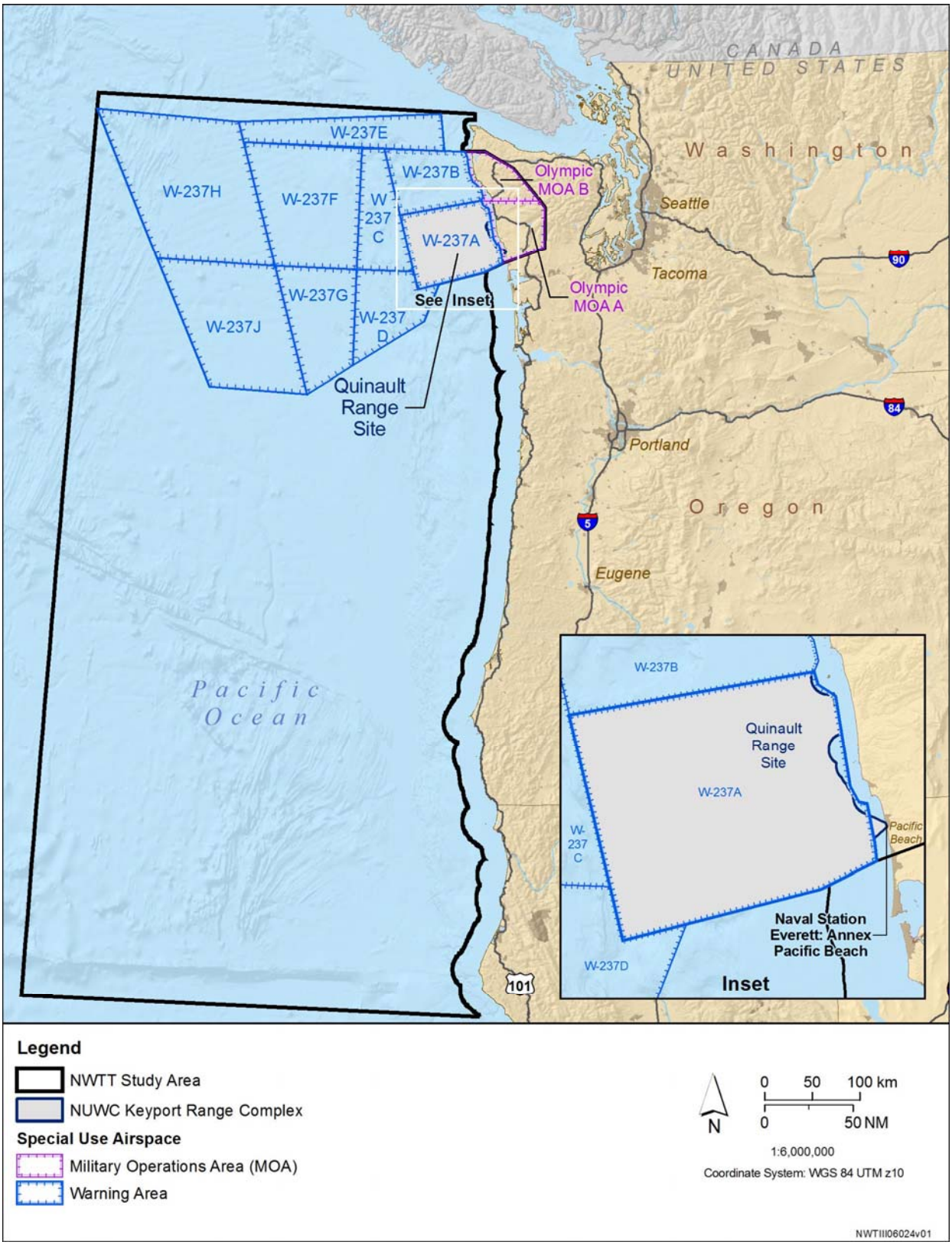


Figure 2-2: Offshore Area of the Northwest Training and Testing Study Area

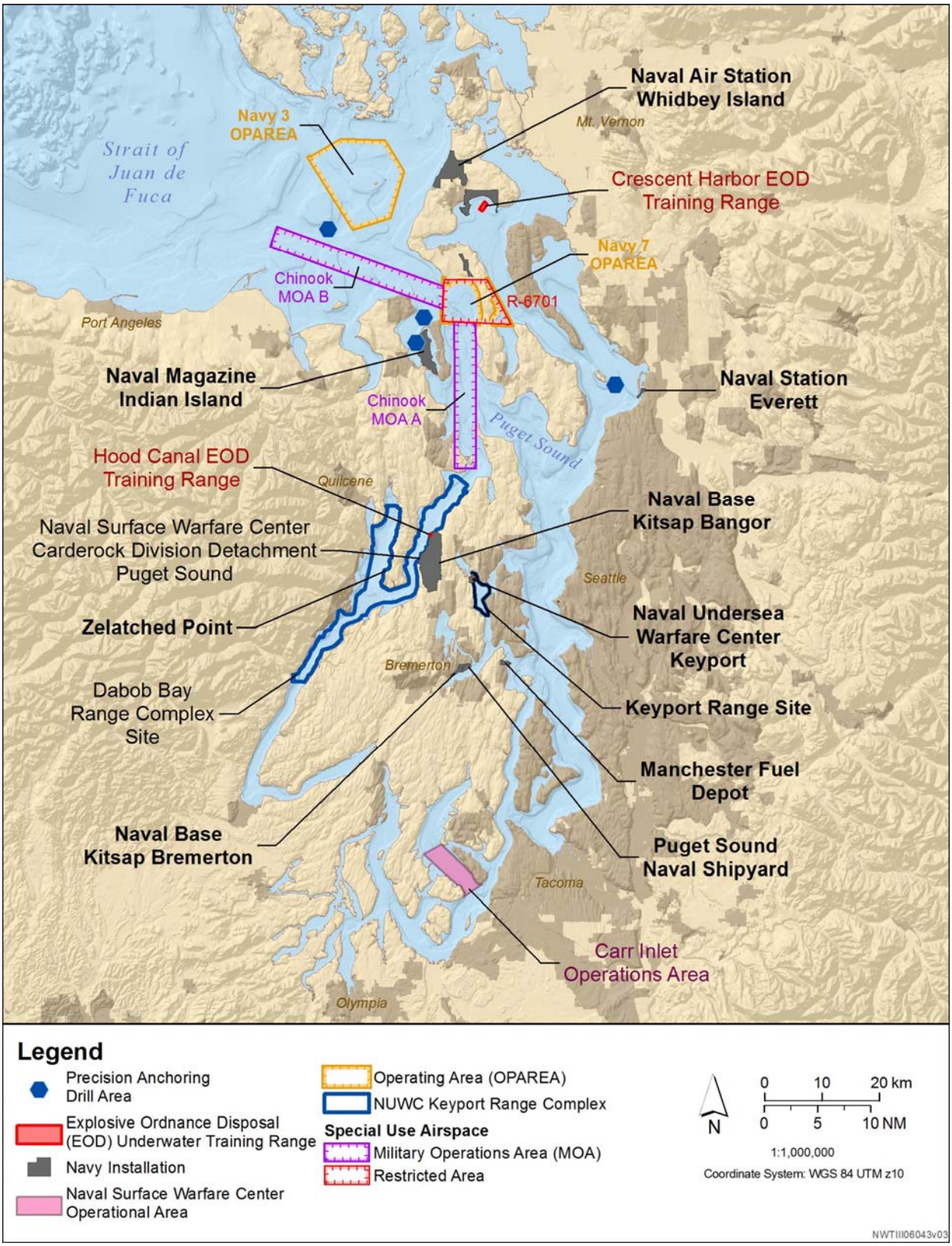


Figure 2-3: Inland Waters of the Northwest Training and Testing Study Area

2.2.2 SEA AND UNDERSEA SPACE

2.2.2.1 Explosive Ordnance Disposal Underwater Ranges

Two active EOD ranges are located in the Inland Waters at the following locations, as depicted by Figure 2-3:

- Hood Canal EOD Training Range
- Crescent Harbor EOD Training Range

The EOD training ranges are also used for swimmer training during mMine countermeasure activities.

2.2.2.2 Surface and Subsurface Testing Sites

There are three geographically distinct range sites in the Inland Waters where the Navy conducts surface and subsurface testing and some limited training. The Keyport Range Site is located in Kitsap County and includes portions of Liberty Bay and Port Orchard Reach (also known as Port Orchard Narrows). The Dabob Bay Range Complex (DBRC) Site is located in Hood Canal and Dabob Bay, in Jefferson, Kitsap, and Mason counties. The Carr Inlet OPAREA is located in southern Puget Sound.

The Keyport Range Site is located adjacent to Naval Base (NAVBASE) Kitsap, Keyport, providing approximately 3.2 NM^2 for testing, including in-shore shallow water sites and a shallow lagoon to support integrated undersea warfare systems and vehicle maintenance and engineering activities. Water depth at the Keyport Range Site is less than 100 ft. Underwater tracking of test activities can be accomplished by using temporary or portable range equipment. The Navy has conducted testing at the Keyport Range Site since 1914.

The DBRC Site includes the Dabob Bay and the Hood Canal from 1 mi. south of the Hood Canal Bridge to the Hamma Hamma River, a total area of approximately 45.7 NM^2. The Navy has conducted underwater testing at the DBRC Site since 1956, beginning with a control center at Whitney Point. The control center was subsequently moved to Zelatched Point.

Dabob Bay is a deep-water area in Jefferson County approximately 14.5 NM^2 in size and contains an acoustic tracking range. The acoustic tracking space within the range is approximately 7.3 NM by 1.3 NM (9 NM^2) with a maximum depth of 600 ft.. The Dabob Bay tracking range, the only component of the DBRC Site with extensive acoustic monitoring instrumentation installed on the seafloor, provides for object tracking, communications, passive sensing, and target simulation. Many activities conducted within Dabob Bay are supported by land-based facilities at Zelatched Point.

Hood Canal averages a depth of 200 ft. and is used for vessel sensor accuracy tests and launch and recovery of test systems where tracking is optional.

The Carr Inlet OPAREA is a quiet deep-water inland range approximately 12 NM^2 in size. It is located in an arm of water between Key Peninsula and Gig Harbor Peninsula. Its southern end is connected to the southern basin of Puget Sound. Northward, it separates McNeil Island and Fox Island as well as the peninsulas of Key and Gig Harbor. The acoustic tracking space within the range is approximately 6 NM by 2 NM with a maximum depth of 545 ft.. The Navy performed underwater acoustic testing at Carr Inlet from the 1950s through 2009, when activities were relocated to NAVBASE Kitsap, Bangor. While no

permanently installed structures are present in the Carr Inlet OPAREA, the waterway remains a Navy-restricted area.

2.2.2.3 Pierside Testing Facilities

In addition to the training and testing ranges, at which most of the training and testing assessed in this document occurs, the Navy conducts some testing at or near Navy piers. Most of this testing is sonar maintenance and testing while ships are in port for maintenance or system re-fitting. These piers within the Study Area are all within Puget Sound and include the NAVBASE Kitsap, Bremerton in Sinclair Inlet; NAVBASE Kitsap, Bangor Waterfront in Hood Canal, and Naval Station Everett (see Figure 2-3).

2.2.2.4 Navy Surface Operations Areas

In addition to the areas mentioned above, there are two surface and subsurface operations areas used for Navy training and testing within the Inland Waters. Navy 3 OPAREA is a surface and subsurface area off the west coast of northern Whidbey Island. Navy 7 OPAREA is the surface and subsurface area that lies beneath R-6701. This area covers a total area of 61 NM^2.

2.3 Western Behm Canal, Alaska

The Western Behm Canal is located in Southeast Alaska, near the city of Ketchikan, Alaska. The Southeast Alaska Acoustic Measurement Facility (SEAFAC) is located in the Western Behm Canal and covers an area of 48 NM^2. The U.S. Navy has been conducting testing activities at SEAFAC since 1992. The facility replaced the Santa Cruz Acoustic Range Facility in Southern California and is now the location for some acoustic testing previously conducted at the NSWC Carr Inlet Acoustic Range in Washington State.

SEAFAC is comprised of land-based facilities and in-water assets. The land-based facilities are located within 5.5 acres (2 hectares) on Back Island and are not included in the scope of this analysis. The operational area of SEAFAC are located in five restricted areas. The underway site arrays are in Area 1. The static site is in Area 2. All associated underwater cabling and other devices associated with the underway site are located in Area 3. Area 4 provides a corridor for utility power and a phone cable. Area 5 encompasses the entire operational area and allows for safe passage of local vessel traffic. Notifications of invoking restriction of Area 5 occur at least 72 hours prior to SEAFAC operations in accordance with 33 C.F.R. § 334.1275. During test periods, all vessels entering Area 5 are requested to contact SEAFAC to coordinate safe passage through the area. Area 5 defines the SEAFAC Study Area boundary, which is comprised only of the in-water area and excludes the land-based supporting facilities and operations. These areas are all depicted in Figure 2-4.

The SEAFAC at-sea areas are:

- Restricted Areas 1 through 5. The five restricted areas are located within Western Behm Canal. The main purposes of the restricted areas are to provide for vessel and public safety, lessen acoustic encroachment from non-participating vessels, and prohibit certain activities that could damage SEAFAC's sensitive in-water acoustic instruments and associated cables. Area 5 encompasses the entire SEAFAC operations area.
- Underway Measurement Site. The underway measurement site is in the center of Western Behm Canal and is 5,000 yards (yd.) wide and 12,000 yd. long. The acoustic arrays are located at the center of this area (Area 1).

- Static Site. The static site is approximately 2 NM northwest of Back Island. During testing, a vessel is tethered between two surface barges. In most scenarios, the vessel submerges to conduct acoustic measurements. The static site is located at the center of Area 2.
- Area 3 and Area 4. These restricted areas provide protection to underwater cables and the bottom-mounted equipment they encompass.

Bottom-moored acoustic measurement arrays are located in the middle of the site. These instrumented arrays are established for measuring vessel signatures when a vessel is underway (underway site) or is at rest and moored (static site). The instruments are passive arrays of hydrophones sensing the acoustic signature of the vessels (i.e., the sounds emitted when sonar units are not in operation). Hydrophones on the arrays pick up noise in the water and transmit it to shore facilities, where the data are processed. SEAFAC's sensitive and well-positioned acoustic measurement equipment provides the ability to listen to and record the radiated signature of submarines, as well as other submerged manned and unmanned vehicles, selected National Oceanic and Atmospheric Administration surface vessels, and cruise ships.

The sensors at SEAFAC are passive and measure radiated noise in the water, such as machinery on submarines and other underwater vessels. Vessels do not use tactical mid-frequency active sonar while undergoing testing at SEAFAC. Active acoustic sources are used for communications, range calibration, and to provide position information for units operating submerged on the range.

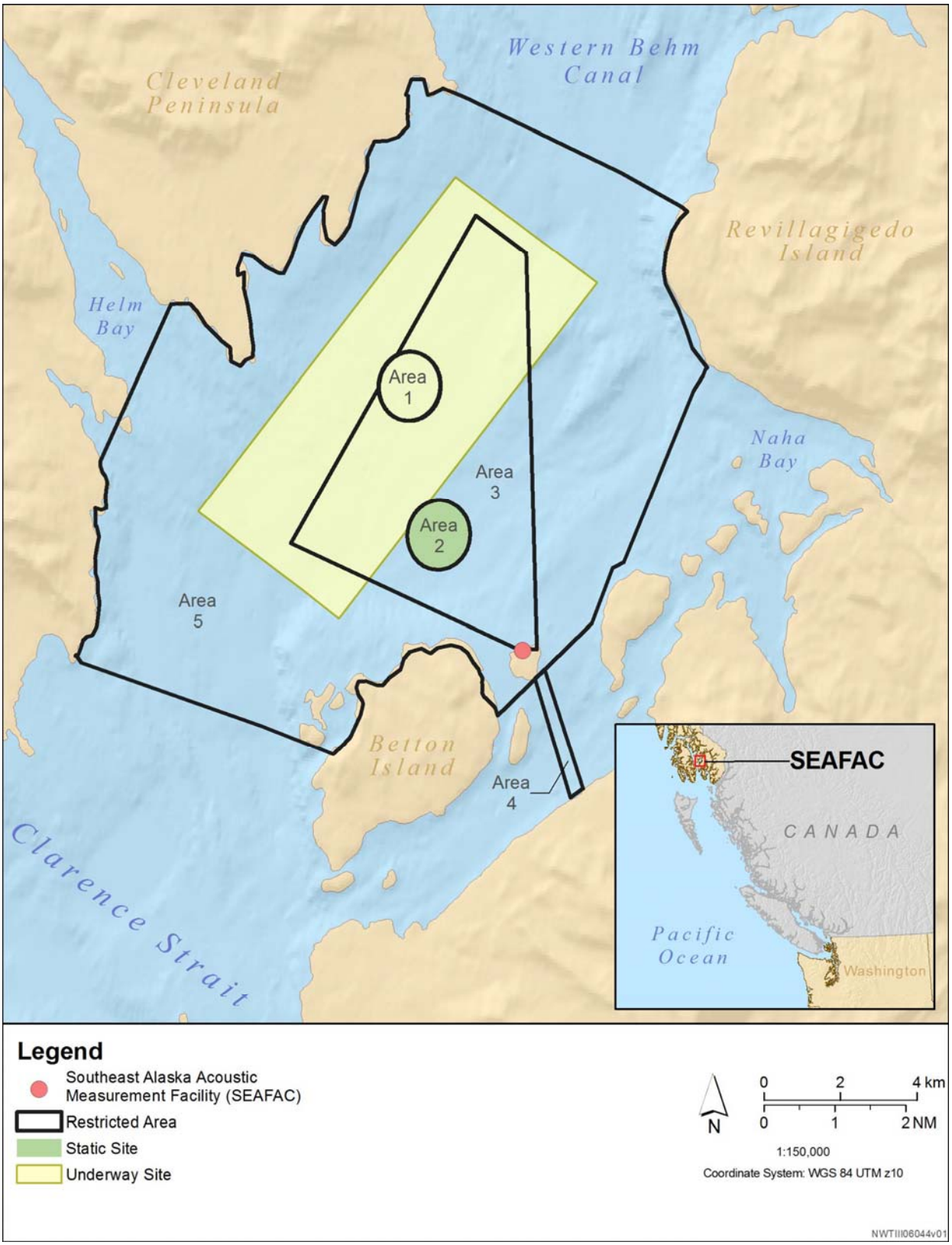


Figure 2-4: Southeast Alaska Acoustic Measurement Facility

3 Species and Numbers of Marine Mammals

3.1 Species Known to Occur in the Study Area

Marine mammal species expected to be present in the Study Area are provided in Table 3-1 and listed alphabetically within the suborder groupings. The information presented in this Request for LOAs incorporates data from the U.S. Pacific and the Alaska Marine Mammal Stock Assessments (Carretta et al., 2017c; Muto et al., 2017), which cover some of those species present in the Study Area and incorporate the best available science, including monitoring data from Navy marine mammal research efforts. For those few species for which stock information exists for the Study Area, relevant data are included in the species-specific Status and Management summaries provided in Chapter 4 (Affected Species Status and Distribution).

3.2 Species Unlikely to Occur in the Study Area

The species carried forward for analysis are those likely to be found in the Study Area based on the most recent data available, and do not include species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which were extirpated from factors such as 19th and 20th century commercial exploitation). Several species that may be present in the northwest Pacific Ocean have an extremely low probability of presence in the Study Area. These species are considered extralimital, meaning there may be a small number of sighting or stranding records within the Study Area, but the area of concern is outside the species range of normal occurrence. These species include Bryde's whale (*Balaenoptera brydei/edeni*), false killer whale (*Pseudorca crassidens*), and long-beaked common dolphin (*Delphinus capensis*), which have been excluded from further discussion and analysis.

1 **Table 3-1: Marine Mammals Occurrence Within the NWTT Study Area**

Common Name	Stock	Scientific Name	Stock Abundance[1] Best	Status		Occurrence		
				MMPA	ESA	Offshore Area	Inland Waters	Western Behm Canal
MYSTICETES								
Blue whale	Eastern North Pacific	*Balaenoptera musculus*	1,647	D	E	Seasonal	-	-
Fin whale	Northeast Pacific stock	*Balaenoptera physalus*	2,554	D	E	-	-	Rare
	California, Oregon, and Washington stock		9,029	D	E	Seasonal	Rare	-
Gray whale	Eastern North Pacific stock	*Eschrichtius robustus*	26,960	-	n/a	Seasonal	Seasonal	-
	Western North Pacific stock		175	D	E	Rare	Rare	-
Humpback whale	Central North Pacific stock	*Megaptera novaeangliae*	10,103	-	T/E[2]	Regular	Regular	Regular
	California, Oregon, and Washington stock		2,900	D	T/E[2]	Regular	Regular	Regular
Minke whale	Alaska stock	*Balaenoptera acutorostrata*	389	-	n/a	-	-	Rare
	California, Oregon, and Washington stock		636	-	n/a	Regular	Seasonal	-
North Pacific right whale	Eastern North Pacific	*Eubalaena japonica*	31	D	E	Rare	-	-
Sei whale	Eastern North Pacific	*Balaenoptera borealis*	519	D	E	Regular	-	-
ODONTOCETES								
Baird's beaked whale	California, Oregon, and Washington stock	*Berardius bairdii*	2,697	-	n/a	Regular	-	-
Common bottlenose dolphin	California, Oregon, and Washington	*Tursiops truncatus*	1,924	-	n/a	Regular	-	-
Cuvier's beaked whale	Alaska stock	*Ziphius cavirostris*	n/a	-	n/a	-	-	-
	California, Oregon, and Washington stock		3,274	-	n/a	Regular	-	-
Dall's porpoise	Alaska stock	*Phocoenoides dalli*	83,400	-	n/a	-	-	Regular
	California, Oregon, and Washington stock		25,750	-	n/a	Regular	Regular	-
Dwarf sperm whale	California, Oregon, and Washington	*Kogia sima*	2,106	-	n/a	Rare	-	-
Harbor porpoise	Southeast Alaska stock	*Phocoena phocena*	896	-	n/a	-	-	Regular
	Northern Oregon/Washington Coast stock		21,487	-	n/a	Regular	-	-
	Northern California/Southern Oregon stock		35,769	-	n/a	Regular	-	-
	Washington Inland Waters stock		11,233	-	n/a	-	Regular	-
Killer whale	Eastern North Pacific Alaskan Resident stock	*Orcinus orca*	2,347	-	n/a	-	-	Regular
	Eastern North Pacific Northern Resident stock		261	-	n/a	Seasonal	Seasonal	-

Common Name	***Stock***	***Scientific Name***	***Stock Abundance[1] Best***	***Status***		***Occurrence***		
				MMPA	***ESA***	***Offshore Area***	***Inland Waters***	***Western Behm Canal***
	West Coast Transient stock		243	-	n/a	Regular	Regular	Regular
	Eastern North Pacific Offshore stock		300	-	n/a	Regular	-	Regular
	Eastern North Pacific Southern Resident stock		77	D	E	Seasonal	Regular	-
Mesoplodont beaked whales	California, Oregon, and Washington	*Mesoplodon spp.*	3,044	-	n/a	Regular	-	-
Northern right whale dolphin	California, Oregon, and Washington	*Lissodelphis borealis*	26,556	-	n/a	Regular	-	-
Pacific white-sided dolphin	North Pacific stock	*Lagenorhynchus obliquidens*	26,880	-	n/a	-	-	Regular
	California, Oregon, and Washington stock		26,814	-	n/a	Regular	Regular	-
Pygmy sperm whale	California, Oregon, and Washington	*Kogia breviceps*	4,111	-	n/a	Regular	-	-
Risso's dolphin	California, Oregon, and Washington	*Grampus griseus*	6,336	-	n/a	Regular	Rare	-
Short-beaked common dolphin	California, Oregon, and Washington	*Delphinus delphis*	969,861	-	n/a	Regular	Rare	-
Short-finned pilot whale	California, Oregon, and Washington	*Globicephala macrorhynchus*	836	-	n/a	Regular	Rare	-
Sperm whale	California, Oregon, and Washington stock	*Physeter macrocephalus*	1,997	D	E	Rare	-	-
Striped dolphin	California, Oregon, and Washington	*Stenella coeruleoalba*	29,211	-	n/a	Regular	-	-
PINNIPEDS								
California sea lion	U.S. Stock	*Zalophus californianus*	257,606	-	n/a	Seasonal	Regular	-
Guadalupe fur seal	Mexico to California	*Arctocephalus townsendi*	26,960	D	T	Seasonal	-	-
Harbor seal	Southeast Alaska (Clarence Strait) stock	*Phoca vitulina*	31,634	-	n/a	-	-	Regular
	Oregon/Washington Coast stock		24,732	-	n/a	Regular	Seasonal	-
	California stock		30,968	-	n/a	Regular	-	-
	Washington Northern Inland Waters stock		11,036	-	n/a	Seasonal	Regular	-
	Hood Canal stock		1,088	-	n/a	Seasonal	Regular	-
	Southern Puget Sound stock		1,568	-	n/a	Seasonal	Regular	-
Northern elephant seal	California	*Mirounga angustirostris*	179,000	-	n/a	Regular	Regular	Seasonal
Northern fur seal	Eastern Pacific stock	*Callorhinus ursinus*	620,660	D	n/a	Regular	-	Seasonal
	California stock		14,050	-	n/a	Regular	-	-
Steller sea lion	Eastern U.S. stock	*Eumetopias jubatus*	21,638	-	n/a	Regular	Seasonal	Regular
	Western U.S. stock		54,267	D	E	Rare	-	Rare

Common Name	***Stock***	***Scientific Name***	***Stock Abundance[1] Best***	***Status***		***Occurrence***		
				MMPA	***ESA***	***Offshore Area***	***Inland Waters***	***Western Behm Canal***

Notes: ESA = Endangered Species Act; D = Depleted; n/a = status is not applicable for those species that are not listed under ESA; T = Threatened; E = Endangered; U.S. = United States; Regular = a species that occurs as a regular or usual part of the fauna of the area, regardless of how abundant or common it is; Seasonal = species is only seasonally present in the NWTT Study Area; Rare = a species that occurs in the area sporadically and numbering only a few individuals; Extralimital = a species not expected to be in the designated area. Additional details regarding presence in the NWTT Study Area are provided in the species-specific subsections.

[1] Stock abundance best are numbers provided by the Pacific and Alaska Stock Assessment Reports (Carretta et al., 2016c; Carretta et al., 2018b; Muto and Angliss 2015; Muto et al., 2016; Muto et al., 2018b). The stock abundance is an estimate of the number of animals within the stock.

[2] Humpback whales in the Central North Pacific stock and the California, Oregon, and Washington stock are from three Distinct Population Segments based on animals identified in breeding areas in Hawaii, Mexico, and Central America. Both stocks and all three DPSs co-occur in the NWTT Study Area.

1

4 Affected Species Status and Distribution

The marine mammal species discussed in this section are those for which general regulations governing potential incidental takes of small numbers of marine mammals are sought. Relevant information on their status, distribution, and seasonal distribution (when applicable) is presented below, as well as additional information about the numbers of marine mammals likely to be found within the activity areas. Additional information on the general biology and ecology of marine mammals are included in the NWTT Draft Supplemental EIS/OEIS (U.S. Department of the Navy, 2019b). In addition, NMFS annually publishes stock assessment reports (SARs) for all marine mammals in U.S. Exclusive Economic Zone (EEZ) waters, including stocks that occur within the NWTT Study Area (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2018a). Figure 4-1 is provided as a bathymetric reference for the descriptions that follow.

4.1 Mysticetes

4.1.1 Blue Whale (*Balaenoptera musculus*)

4.1.1.1 Status and Management

The blue whale is listed as endangered under the ESA, but there is no designated critical habitat for this species. NMFS has determined that more research is still needed to rigorously and specifically define the features that make habitat important to blue whales (National Marine Fisheries Service, 2018b). The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. In the Study Area, the subspecies *Balaenoptera musculus* is present. As presented in the Pacific SAR, the Eastern North Pacific stock of blue whales includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific, and the stock is considered depleted under the MMPA throughout its range (Carretta et al., 2017c; Carretta et al., 2018b).

4.1.1.2 Geographic Range and Distribution

The Eastern North Pacific Stock of blue whales includes animals found in the eastern north Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al., 2017c; Carretta et al., 2018b). Based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, relatively low densities of blue whales are predicted in the Study Area during the summer and fall (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2016; Forney et al., 2012).

Most blue whale sightings are in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration, and like many mysticetes spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al., 2004). Blue whales in the eastern north Pacific are known to migrate between higher latitude feeding grounds of the Gulf of Alaska and the Aleutian Islands to lower latitudes, including Southern California, Baja California, Mexico and the Costa Rica Dome (Calambokidis & Barlow, 2004; Calambokidis et al., 2009a; Calambokidis et al., 2009b; Calambokidis & Barlow, 2013; Mate et al., 2015b; Mate et al., 2016, 2017). Blue whales tagged in Southern California waters along the Pacific coastline have been documented moving south to approximately 7 degrees north latitude (just north of the equator) and north to 50 degrees north latitude (British Columbia, Canada) (Mate et al., 2015b; Mate et al., 2016, 2017). Photographs of blue whales off California have been matched to individuals photographed off the Queen Charlotte Islands in northern British Columbia and the northern Gulf of Alaska (Calambokidis et al., 2009b). Parts of the West Coast are known to be blue whale feeding

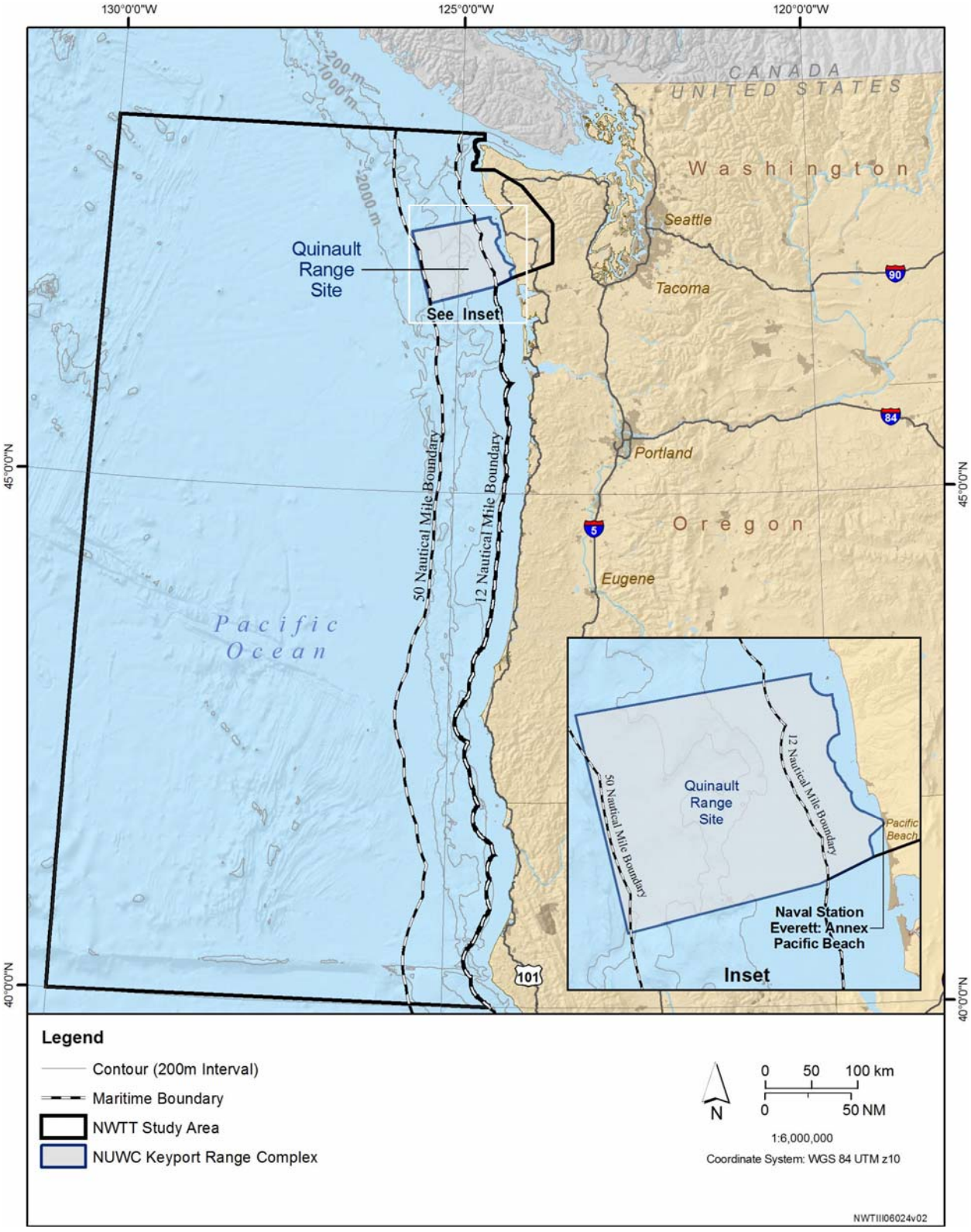


Figure 4-1: Bathymetry of the Offshore Area

areas for the Eastern North Pacific stock during summer and fall (Bailey et al., 2009; Calambokidis et al., 2009a; Calambokidis et al., 2009b; Mate et al., 2017). There have been nine feeding areas identified for blue whales off the U.S. West Coast (Calambokidis et al., 2015), but none of these areas are within the Study Area.

Offshore. In 42 small boat surveys from Grays Harbor out to the 1,000 m isobath off Quinault conducted over a five-year period in the summer between 2004 and 2009, there was one sighting of a blue whale (Oleson & Hildebrand, 2012). In December 2011, six blue whales were sighted off the Washington coast, which was the highest number of blue whales ever sighted off that coast and only the third confirmed sighting in 50 years (Cascadia Research, 2012). Model predictions based on tagging data indicated the highest blue whale presence off Washington in June and July with a presence into November (Hazen et al., 2016). Aerial surveys conducted in waters off southern Washington, Oregon, and Northern California covering the approximate nearshore half of the Study Area in the spring, summer, and fall of 2011 and 2012 encountered a total of 16 blue whales only during the fall and only off Oregon (Adams et al., 2014). Acoustic monitoring in waters off the coast of Washington suggested a yearly seasonal pattern of blue whale presence from summer through winter (calls were absent from approximately March through July) (Debich et al., 2014; Kerosky et al., 2013; Oleson & Hildebrand, 2012; Trickey et al., 2015; Wiggins et al., 2017). For purposes of the analysis in this Request for LOAs, blue whales in the Offshore portion of the Study Area are considered to have a seasonal presence.

Inland Waters. Blue whales are not expected to occur within the Inland Waters region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

Western Behm Canal, Alaska. Blue whales are not expected to occur within the SEAFAC region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

4.1.1.3 Population and Abundance

Widespread whaling over the last century is believed to have decreased the global blue whale population to approximately 1 percent of its pre-whaling population size (Branch, 2007; Branch et al., 2007; Monnahan, 2013; Monnahan et al., 2014; Rocha et al., 2014; Širović et al., 2004). Off the U.S. West Coast, there has been an increase in the blue whale population size (Barlow, 1994, 1997, 2003), with the highest estimate of abundance in that region in 2014 (Barlow, 2016). A previous suggested decline in the population between 2001 and 2005 (Barlow & Forney, 2007) was likely due to variability in the distribution patterns of blue whales off the coast of North America rather than a true population decline (Barlow, 1997, 2003, 2010; Calambokidis et al., 2009a). Calambokidis et al. (2009a) suggested that when feeding conditions off California are not optimal, blue whales may move to other regions to feed, including waters further north. There has been a northward shift in blue whale distribution within waters off California, Oregon, and Washington (Barlow, 2010, 2016; Carretta et al., 2013a; Širović et al., 2015b). Subsequent mark-recapture estimates reported by Calambokidis et al. (2009a) indicated, “a significant upward trend in abundance of blue whales“ at a rate of increase just under 3 percent per year for the U.S. West Coast blue whale population (see also Calambokidis and Barlow (2013)).

The most current information suggests that the Eastern North Pacific population in the Study Area may have recently recovered from commercial whaling, which ended in 1971 (Barlow, 1997, 2003, 2016; Calambokidis & Barlow, 2013; Campbell et al., 2015; Carretta et al., 2017c; Carretta et al., 2018b; International Whaling Commission, 2016; Monnahan, 2013; Monnahan et al., 2014; Monnahan et al., 2015; Rockwood et al., 2017; Širović et al., 2015b). Based on NMFS systematic ship surveys from 1991 to

2014, the abundance of blue whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 352 animals (Barlow, 2016).

4.1.2 Fin Whale (*Balaenoptera physalus*)

4.1.2.1 Status and Management

The fin whale is listed as endangered under the ESA, but there is no designated critical habitat for this species. Fin whale population structure in the Pacific Ocean is not well known. During the 20th century more fin whales were taken by industrialized whaling than any other species (Rocha et al., 2014). In the Study Area, NMFS recognizes two fin whale stocks: (1) the Northeast Pacific stock (Alaska); and (2) the California, Oregon, and Washington stock. Both stocks are considered depleted under the MMPA (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017; Muto et al., 2018b).

4.1.2.2 Geographic Range and Distribution

Fin whales have been documented from 60° North (N) in Alaska waters, to tropical waters off Hawaii, and in Canadian waters both offshore and inland, including some fjords; and they have frequently been recorded in waters within the Southern California Bight (Barlow & Forney, 2007; Campbell et al., 2015; Jefferson et al., 2014; Mate et al., 2016, 2017; Mizroch et al., 2009; Širović et al., 2004; Širović et al., 2015b; Širović et al., 2016; Smultea, 2014). When seasonally present in Northern British Columbia waters of Hecate Strait, Queen Charlotte Sound, and Greater Caamaño Sound, satellite tag data and photographic identifications indicated little movement of fin whales between the inshore areas and the offshore regions of the Canadian Pacific (Nichol et al., 2018). As demonstrated by satellite tags and discovery tags,[2] fin whales make long-range movements along the entire U.S. West Coast (Falcone et al., 2011; Mate et al., 2015b; Mate et al., 2016, 2017; Mizroch et al., 2009). Locations of breeding and calving grounds are largely unknown. The species is highly adaptable, following prey, typically off the continental shelf (Azzellino et al., 2008; Panigada et al., 2008), and survey data indicate that fin whale distributions shift both seasonally as well as annually (Calambokidis et al., 2015; Douglas et al., 2014; Jefferson et al., 2014).

Offshore. In 42 small boat surveys from Grays Harbor out to the 1,000 m isobath off Quinault conducted over a five-year period in the summer between 2004 and 2009, there was one sighting of a group of three fin whales (Oleson & Hildebrand, 2012). (Adams et al., 2014) conducted aerial surveys within the 2,000 m isobath off southern Washington, Oregon, and Northern California in January, June, and October of 2011 and February, July, and September of 2012. Fin whales were only sighted during the February and July surveys in 2012, during which six sightings of 13 fin whales were recorded in waters over the continental slope ranging from 200 to 2,000 m in depth. Between 2014 and 2017, 32 fin whales were instrumented with satellite tags in the waters off the U.S. West Coast (Mate et al., 2017; U.S. Department of the Navy, 2018a); all these whales are from the same stock as present in the NWTT Study Area. Only four of the 32 fin whales ventured into the NWTT Study Area; one only as far north as the California/Oregon border. One of the three fin whales present as far north as waters off Washington only passed through the NWTT Study Area briefly on its way further north into Canadian waters. Across the tag data sample years, fin whale use of the NWTT Study Area occurred primarily in late summer and

[2] As a means of data collection starting in the 1930s, discovery tags having a serial number and return address were shot into the blubber of the whale by scientists; if that whale was later harvested by the whaling industry and the tag "discovered" during flensing, it could be sent back to the researchers, providing data on the movement of individual whales.

fall (Mate et al., 2017; U.S. Department of the Navy, 2018a). Consistent with sightings from systematic ship surveys out to 300 NM off the U.S. West Coast and satellite tag data, and habitat-based density models built with these data, fin whales are more likely to be present seaward of the continental shelf in the offshore portion of the Study Area (Barlow, 2016; Becker et al., 2016).

Acoustic monitoring has indicated a yearly seasonal pattern of fin whale calls in the Study Area off Washington and Canada, with the absence of calls from approximately May through July (Debich et al., 2014; Kerosky et al., 2013; Oleson & Hildebrand, 2012; Trickey et al., 2015; Wiggins et al., 2017). Consistent with those findings and the satellite tag data, a seafloor seismic network at the Strait of Juan de Fuca was used to study fin whale calls and suggested northward movement of transiting fin whale groups from August to October and a southward movement from November to April (Soule & Wilcock, 2013). For purposes of the analysis in this Request for LOAs, fin whales in the Offshore portion of the Study Area are considered to have a regular presence.

Inland Waters. Fin whales are not expected to occur within the Inland Waters region of the Study Area. Lone fin whales were sighted in the Strait of Juan de Fuca between September and December 2015, in July 2016, and again in October 2017; these were three of only 10 total fin whale sightings in the Salish Sea since 1930 (Cogan, 2015; Daugherty, 2016; Towers et al., 2018).

Western Behm Canal, Alaska. Surveys in Southeast Alaska between 1991 and 2007 encountered a total of seven fin whales, only in the summer, and only off the southern tip of Prince of Wales Island and the southern end of Clarence Strait in proximity to the open ocean (Dahlheim et al., 2009). The limited number of sightings from those surveys and a documented presence limited to a proximity to the open ocean suggests fin whale presence in Behm Canal would be rare. Based on the sighting of fin whales in Clarence Strait (Dahlheim et al., 2009), and for purposes of the present analysis, the Navy assumes fin whales may be present in small numbers within the SEAFAC region of the Study Area.

4.1.2.3 Population and Abundance

There are no reliable current or historical population estimates for the Alaska/Northeast Pacific stock of fin whales (Muto et al., 2017). Suggested evidence of an increasing abundance trend for fin whales in Alaskan waters (Zerbini et al., 2006) is consistent with their suggested increase off the U.S. West Coast (Barlow, 2016; Jefferson et al., 2014; Moore & Barlow, 2011; Širović et al., 2015b).

Based on systematic ship survey data collected off the U.S. West Coast from 1991 to 2014, the fin whale is by a large margin the most abundant large whale found in those waters (Barlow, 2016). For the Offshore portion of the Study Area and based on surveys from 1991 to 2014, the abundance for fin whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 2,628 animals (Barlow, 2016). It has been suggested that the increasing number of fin whales seen since 1999 between Vancouver Island and Washington, "… may reflect recovery of the local populations in the North Pacific" (Towers et al., 2018).

4.1.3 Gray Whale (*Eschrichtius robustus*)

4.1.3.1 Status and Management

There are two north Pacific populations of gray whales: the Eastern subpopulation and the Western subpopulation designated in the Pacific SAR (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017; Weller et al., 2013). Both populations could be present in the Study Area during their northward

and southward migration (Calambokidis et al., 2017b; Mate et al., 2015a; Sumich & Show, 2011; Weller et al., 2013).

The Eastern North Pacific subpopulation (also known as the California-Chukchi population) has recovered from whaling exploitation and was delisted under the ESA in 1994 (Swartz et al., 2006). This population has been designated the Eastern North Pacific stock and is not considered depleted (Carretta et al., 2017c).

The Western subpopulation, which was previously also known as the western north Pacific or the Korean-Okhotsk population, has been designated the Western North Pacific stock and is considered depleted (Carretta et al., 2017c; Cooke et al., 2015; Weller et al., 2002; Weller et al., 2013). This subpopulation is critically endangered, shows no apparent signs of recovery, and should be very few in number in the Study Area given the small population and their known wintering areas in waters off Russia and Asia (Weller et al., 2013).

4.1.3.2 Geographic Range and Distribution

It should be noted that most of the science dealing with gray whale migrations and distribution is not specific to either of the two recognized gray whale sub-populations, but where possible that distinction has been specified in the following sections.

Along the Pacific coast between Alaska and Northern California, there are a few hundred gray whales present throughout the summer and fall that are known as the Pacific Coast Feeding Group, which are assumed to be part of the Eastern population (Calambokidis et al., 2002; Carretta et al., 2017c; Mate et al., 2010; Mate, 2013; Weller et al., 2013). The group has been identified as far north as Kodiak Island, Alaska (Gosho et al., 2011), and has generated uncertainty regarding the stock structure of the Eastern North Pacific population (Carretta et al., 2017c; Weller et al., 2012; Weller et al., 2013). Survey and photo identifications work undertaken along the Washington coast from 1984 to 2011 observed a total of 225 unique gray whales, with 49 percent being observed again in a future year (Scordino et al., 2017). Photo-identification, telemetry, and genetic studies suggest that the Pacific Coast Feeding Group is a distinct feeding aggregation from the Eastern North Pacific population (Calambokidis et al., 2010; Frasier et al., 2011; International Whaling Commission, 2014; Mate et al., 2010; Weller et al., 2013). In 2012–2013, the Navy funded a satellite tracking study of Pacific Coast Feeding Group gray whales (Mate, 2013). Tags were attached to 11 gray whales near Crescent City, California, in fall 2012. Track histories were received from nine of the 11 tags, which confirmed an exclusive near shore (< 19 km) distribution and movement along the Northern California, Oregon, and Washington coasts (Mate, 2013). Although the duration of the tags was limited, none of the Pacific Coast Feeding Group whales moved south beyond Northern California. The Pacific Coast Feeding Group is not currently treated as a distinct stock or population segment (Carretta et al., 2015; Carretta et al., 2017c; Mate et al., 2010). Within the Inland Waters portion of the NWTT Study Area, there is also a group of gray whales that feed locally each spring in the inland waters around Whidbey Island and Camano Island (Cascadia Research, 2017b; Cogan, 2015). Five of the photo-identified individuals in this group have been seen over the last 17 years, and three have been sighted over at least 26 years (Cascadia Research, 2017b).

Gray whales of the Western North Pacific stock primarily occur in shallow waters over the U.S. West Coast, Russian, and Asian continental shelves and are considered to be one of the most coastal of the great whales (Jefferson et al., 2015; Jones & Swartz, 2009). Feeding grounds for the population are the Okhotsk Sea off Sakhalin Island, Russia; and in the southeastern Kamchatka Peninsula (in the

southwestern Bering Sea) in nearshore waters generally less than 225 ft. deep (Jones & Swartz, 2009; Weller & Brownell, 2012). The winter breeding grounds for the Western North Pacific stock may be areas in the South China Sea (Weller et al., 2013). The breeding grounds for the Eastern North Pacific stock consist of subtropical lagoons in Baja California, Mexico, and suspected wintering areas in southeast Asia (Alter et al., 2009; Jones & Swartz, 2009; Mate et al., 2015a; Urban-Ramirez et al., 2003; Weller et al., 2012).

Gray whales are acoustically active while migrating (Guazzo et al., 2017), and acoustic and sighting data have indicated gray whales use parts of the Washington coast throughout the year (Ferguson et al., 2015b; Oleson & Hildebrand, 2012). The Cetacean Density and Distribution Mapping Working Group (see Ferguson et al. (2015a)) shows the observed presence of gray whales in the Study Area in every month of the year except February. In aerial surveys conducted in waters off Washington, Oregon, and Northern California covering the approximate nearshore half of the Study Area in the spring, summer, and fall of 2011 and 2012, gray whales were present during all surveys and within 25 km of the coast, except for two sightings over deeper water (Adams et al., 2014). In boat surveys between 1984 and 2011 off the Washington coast, gray whales were most commonly observed in very shallow waters with depths ranging from 5 to 15 m over rocky substrates and often near kelp forests (Scordino et al., 2017).

Some gray whales make the longest annual migration of any mammal, 15,000–20,000 km roundtrip (Jones & Swartz, 2009; Mate et al., 2013; Mate et al., 2015a; Weller et al., 2012; Weller et al., 2013). Both the western and eastern populations are now known to overlap in both the northern feeding grounds and in the breeding areas (Weller et al., 2013), so while most gray whales migrating through the Study Area are likely from the eastern population, individuals from the western population may also be present (Carretta et al., 2017c). Long-term studies of radio-tracked whales, improved photographic identification, and genetic studies have detected western population whales along the North American coast from British Columbia, Canada, and as far south as Baja California, Mexico (Mate et al., 2015a; Muir et al., 2016; Weller et al., 2002; Weller et al., 2012; Weller et al., 2013). For purposes of the analysis in this Request for LOAs, it is assumed that a very small percentage of migrating gray whales could be individuals from the endangered Western North Pacific stock.

Gray whales that migrate do so between October and July (Calambokidis et al., 2015), and the majority of gray whales are only present in the Study Area while migrating through those waters. Gray whale individuals identified and observed along the Washington coast had an average minimum residency time in those waters of approximately 25 days out of a possible 183 days of the feeding season (Scordino et al., 2017).

The gray whale migration corridors, a potential presence migration buffer, were identified as biologically important areas (during the months they are cumulatively in use [October through July]) that should be considered given the potential for human activities to impact this important seasonal migration behavior (Calambokidis et al., 2015; Ferguson et al., 2015b; Van Parijs, 2015); see the 2015 NWTT Final EIS/OEIS, Figure 3.4-3. As noted previously, the northern boundary of designated biologically important areas were truncated at a line drawn between the U.S. and Canadian EEZs because the identification of biologically important areas was restricted to locations only in U.S. waters (Calambokidis et al., 2015; Ferguson et al., 2015b). Gray whale migration corridors are contiguous from U.S. waters through Canadian waters (Burnham et al., 2018; Ford et al., 2010), and continuing on into waters off Alaska (Ferguson et al., 2015a). In the designation of biologically important areas (BIAs) to locations only in U.S. waters, it was made clear that, "…the absence of BIA designations outside U.S. waters should not be

interpreted as an absence of BIAs in those waters" (Ferguson et al., 2015b), which is the case for the gray whale migration routes that extend through the NWTT Study Area and northward into Canadian waters, and beyond to Alaska.

Analysis of Navy training and testing activities in relation to these biologically important areas for gray whale migration was previously completed in the 2015 NWTT Final EIS/OEIS (U.S. Department of the Navy, 2015b), evaluated by NMFS in the issuance of the current Letters of Authorization pursuant to the MMPA (National Oceanic and Atmospheric Administration, 2015b), and reviewed by NMFS pursuant to ESA for listed species in the Study Area (National Marine Fisheries Service, 2014). There is no new applicable science that necessitates any changes in those previous analyses. For additional details regarding these analyses, see Section 3.4.2.1 (Acoustic Stressors) and Appendix K (Geographic Mitigation Assessment) in the NWTT Draft Supplemental EIS/OEIS.

In addition to the gray whale migration routes, the distribution of gray whales in the Study Area is driven by the presence of known feeding areas. When feeding in Washington waters, gray whales were most often observed in depths between 5 and 15 m in either kelp forests or emergent offshore rocks (Scordino et al., 2017). There are six feeding locations designated as a biologically important areas in the Pacific Northwest (Calambokidis et al., 2015). Of those six areas, only the Northwestern Washington and the Northern Puget Sound feeding areas are within the Study Area (see the 2015 NWTT Final EIS/OEIS, Figure 3.4-4). Evaluation of Navy training and testing activities in relation to these biologically important feeding areas for gray whale was previously completed in the 2015 NWTT Final EIS/OEIS (U.S. Department of the Navy, 2015b), evaluated by NMFS in the issuance of the current Letters of Authorization pursuant to the MMPA (National Oceanic and Atmospheric Administration, 2015b), and reviewed by NMFS pursuant to ESA for listed species in the Study Area (National Marine Fisheries Service, 2014). There is no new applicable science that necessitates any changes in those previous analyses. For additional details regarding these analyses, see Section 3.4.2.1 (Acoustic Stressors) and Appendix K (Geographic Mitigation Assessment) in the NWTT Draft Supplemental EIS/OEIS.

Offshore. The occurrence of gray whales is considered seasonal and likely in the offshore portion of the Study Area. In 42 small boat surveys from Grays Harbor out to the 1,000 m isobath off Quinault conducted in the summer over a five-year period between 2004 and 2009, there were eight sightings of gray whales (Oleson & Hildebrand, 2012). As noted previously, aerial surveys conducted in waters off Washington, Oregon, and Northern California in the spring, summer, and fall of 2011 and 2012 found gray whales present during all survey periods (Adams et al., 2014). The seasonal increase in the number of gray whales likely to be present in the area while feeding and migrating has been accounted for in the analysis. Four of the five seasonal gray whale feeding areas located along the West Coast of the United States are near but not within the Offshore portion of the Study Area. The fifth feeding area—the Northwest Washington feeding area—partially overlaps with the Offshore Study Area (Aquatic Mammals, 2015; Calambokidis et al., 2015). It is located at the entrance to the Strait of Juan de Fuca and extends offshore approximately 2–4 NM from the coastline. This area is identified as important for feeding gray whales from May through November (approximately seven months) (Calambokidis et al., 2015).

Inland Waters. As gray whales migrate between feeding and breeding grounds, a few enter the Strait of Juan de Fuca to feed in Inland Waters (Cascadia Research, 2017b; Cogan, 2015). Based on data collected from 1984 to 2011 during the feeding season, the observation rate increased to a peak in October in the Strait of Juan de Fuca (Scordino et al., 2017). Gray whales have been detected in Washington inland

waters in all months of the year, with peak abundance from March through June (Calambokidis et al., 2010). Typically fewer than 20 gray whales are documented annually in the inland waters of Washington and British Columbia, based on a review by Orca Network (Calambokidis et al., 2015; Cogan, 2015; Washington Department of Fish and Wildlife, 2013). For purposes of the analysis in this Request for LOAs, gray whales in the Inland Waters portion of the Study Area are considered to have a seasonal presence.

The Cetacean Density and Distribution Mapping Working Group identified a gray whale "Potential Presence" migration area that extends into and includes all U.S. waters from the entrance of the Strait of Juan de Fuca landward (Calambokidis et al., 2015). This portion of the Potential Presence migration area therefore overlaps all the Inland Waters portion of the Study Area. As noted previously, this Potential Presence area is identified as seasonally important from January through July, and October through December; approximately 10 months of the year. In addition, a biologically important feeding area also has been identified in northern Puget Sound located south and east of Whidbey Island and east of Camano Island to Everett (Calambokidis et al., 2015). This feeding area is used in the spring for two to three months, typically beginning in March and generally ending by June (Calambokidis et al., 2015). For further detailed discussion of these gray whale biologically important feeding areas in the Inland Waters portion of the Study Area, see Section 3.4.2.1 (Acoustic Stressors) in the NWTT Draft Supplemental EIS/OEIS.

Western Behm Canal, Alaska. Gray whales were not observed during 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al., 2009), and they are considered extralimital in this region of the Study Area. There are no identified gray whale feeding or migration areas near the Western Behm Canal; the closest being approximately 60 NM to the southwest and out along the Pacific Coast of Southeast Alaska near Dixon Entrance (Ferguson et al., 2015a).

4.1.3.3 Population and Abundance

The population size of the Eastern North Pacific gray whales has increased over several decades (Calambokidis et al., 2017a; Carretta et al., 2018b; Durban et al., 2017; Perryman et al., 2017). Monitoring over the last 30 years has provided data that have indicated the Eastern North Pacific population and stock is within range of its optimum sustainable population, which is consistent with a population approaching the carrying capacity of the environment (Carretta et al., 2017c; Carretta et al., 2018b). The current abundance estimate for the Eastern North Pacific stock is 26,960 gray whales (Carretta et al., 2017c; Carretta et al., 2018b).

The Western North Pacific stock of gray whales was once considered extinct, but now small numbers (approximately 200) are known to exist (Carretta et al., 2017c; Carretta et al., 2018b; Cooke et al., 2015; International Union for Conservation of Nature (IUCN), 2012; International Whaling Commission, 2014; Mate et al., 2015a; Nakamura et al., 2017; Weller et al., 2013). There are no current population trend data available at this time (Carretta et al., 2017c); however, previous data on population growth indicated a positive growth of roughly 2–4 percent per year . A recent increase in the occurrence of gray whales off Japan (Nakamura et al., 2017) is also consistent with a positive population growth for Western North Pacific gray whales. At least 12 members of the Western North Pacific stock have been detected in waters off the Pacific Northwest (Mate et al., 2013; Weller & Brownell, 2012). NMFS reported that 18 Western North Pacific gray whales have been identified in waters far enough south to have passed through Southern California waters (National Marine Fisheries Service, 2014), and although some gray whales have been shown to make mid-ocean migrations (Mate et al., 2015a), Navy assumes

migration to and from Southern California would include passage through the Study Area as well. The current abundance estimate for the Western North Pacific stock is 175 gray whales (Carretta et al., 2017c; Carretta et al., 2018b).

4.1.4 HUMPBACK WHALE (*MEGAPTERA NOVAEANGLIAE*)

4.1.4.1 Status and Management

Humpback whales expected to be present in the Study Area are from three Distinct Population Segments, given they represent populations that are both discrete from other conspecific populations and significant to the species of humpback whales to which they belong (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017; National Marine Fisheries Service, 2016c; Titova et al., 2017). These Distinct Population Segments (DPSs) in the Study Area are based on animals identified from breeding areas in Hawaii, Mexico, and Central America (Bettridge et al., 2015; Carretta et al., 2017c; Carretta et al., 2018b; Darling et al., 1996; Muto et al., 2017; National Marine Fisheries Service, 2016c; Titova et al., 2017; Wade et al., 2016). The portion of the humpback whale population in the Study Area that is from the Hawaii DPS was delisted under the ESA, given that this population segment is believed to have fully recovered and now has an abundance greater than the pre-whaling estimate (Barlow et al., 2011; Bettridge et al., 2015; Muto et al., 2017; National Marine Fisheries Service, 2016c; Wade et al., 2016). Humpback whales in Study Area from the Mexico DPS are listed as threatened, and those from the Central America DPS are listed as endangered under the ESA (National Marine Fisheries Service, 2016c). There has been no designated critical habitat for these ESA-listed humpback whales in the North Pacific (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017). As of the date of this authorization request, NMFS is still developing Critical Habitat for the listed humpback whale DPSs. The Navy will incorporate analysis of proposed Critical Habitat into the analysis in the Draft Supplemental EIS/OEIS and consult with NMFS under ESA with regards to any critical habitat once it has been designated for humpback whales.

In the North Pacific Ocean and under the MMPA, the stock structure of humpback whales is defined by NMFS based on the stock's fidelity to feeding grounds (Bettridge et al., 2015; Carretta et al., 2017c; Muto et al., 2017; National Marine Fisheries Service, 2016c). As a result, the stock designations are inconsistent with the DPS designations,[3] and although NMFS is evaluating the stock structure of

[3] Between 1990 and 1993 in the Okinawa/Osagawara breeding area of the Western North Pacific DPS, a photographically identified female humpback whale was observed on four occasions (once with a calf) and in 1991, this same individual was observed off La Perouse Bank, in Canadian waters (Darling et al., 1996). La Perouse Bank, is centered approximately 20 NM north of the NWTT Study Area. In 1991, only 24 individual humpback whales had been photo-identified during small boat surveys in waters off Northern Washington/British Columbia (Calambokidis et al., 2004) and a total of 177 had been identified in Japan waters (Darling et al., 1996). Given the small sample sizes of the photo-identification data in 1991 for the Western North Pacific DPS in the two areas involved, this one detection may represent a much more prevalent occurrence of Western North Pacific DPS whales in the vicinity of the NWTT Study Area. In addition data provided by Titova et al. (2017), subsequent to the NMFS reviews cited above, found photo-ID matches between humpbacks in Russian waters with 35 animals in Hawaiian breeding grounds and 11 animals in Mexican breeding grounds. These Russian waters/Western North Pacific stock whales are designated in the Alaska stock assessment report as representing the Okinawa/Osagawara/Philippines or Western North Pacific DPS (Muto et al., 2018a). Thus, this new data along with photo-identification data having matches between what are supposed to be separate breeding areas and feeding areas results in further inconsistencies, with the stock structure of Central North Pacific stock whales being the Hawaii DPS, and the California, Oregon, Washington stock being mostly comprised by the Mexico DPS. The Navy's analysis presumes that due the Western North Pacific stock/DPS being few in number and the NWTT Study Area outside their main feeding area in the western North Pacific, Western North Pacific DPS/stock humpback whales are not likely to be present in the NWTT Study Area during or in proximity to any of the proposed training or testing activities. Therefore, Western North Pacific DPS/stock humpback whales will not be affected by the proposed action.

humpback whales under the MMPA, no changes to current stock structure have been provided to date (Carretta et al., 2017c; Muto et al., 2017). The majority of the humpback whales present in the Alaska and Washington portions of the Study Area (that are generally feeding) spend the winter and spring in Hawaii breeding, calving, or nursing (National Marine Fisheries Service, 2016b, 2016g). NMFS has designated those animals from Hawaii that are present in Alaska, British Columbia, and Washington in the summer and early fall as being part of the Central North Pacific stock, given they migrate to those areas in the Central North Pacific to feed (Muto et al., 2017). The stock is not considered depleted under the MMPA. The Central North Pacific stock includes animals that winter in many locations other than Hawaii, such as humpback whales from Mexico (Calambokidis et al., 2008; National Marine Fisheries Service, 2016b; Wade et al., 2016).

The remainder of humpback whales expected to be present in the Study Area are designated by NMFS as being from the California, Oregon, Washington stock. This stock is defined by NMFS as including only those animals that migrate northward from their winter breeding grounds in Mexico and Central America to feeding areas along the U.S. West Coast off the United States, including the waters of the Study Area (Bettridge et al., 2015; Carretta et al., 2017c; National Marine Fisheries Service, 2016b, 2016c, 2016g). The California, Oregon, Washington stock is considered depleted under the MMPA.

4.1.4.2 Geographic Range and Distribution

Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer on high-latitude feeding grounds, including inland waters and fjords, and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs (Barlow et al., 2011; Bettridge et al., 2015; Calambokidis et al., 2010; Calambokidis et al., 2017a; Wade et al., 2016). Based on sightings and habitat models derived from line-transect survey data collected between 1991 and 2014 off the U.S. West Coast, humpback whales are distributed primarily in nearshore waters during the summer and fall, with a significantly greater proportion of the population found farther offshore during the winter (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2016; Becker et al., 2017; Campbell et al., 2015; Forney & Barlow, 1998; Forney et al., 2012). Visual surveys and acoustic monitoring studies have detected humpbacks along the Washington coast year round, with peak occurrence during the summer and fall (Cogan, 2015; Debich et al., 2014; Oleson et al., 2009; Oleson & Hildebrand, 2012; Širović et al., 2012; Trickey et al., 2015).

There have been three locations identified as biologically important humpback whale feeding areas located in or near the offshore portion of the Study Area (Calambokidis et al., 2015). It is important to note there are also other additional important humpback whale feeding areas used by the same stocks of humpback whales, which are outside of the Study Area (Ashe et al., 2013; Best et al., 2015; Dalla-Rosa et al., 2012; Ferguson et al., 2015a; Keen et al., 2018). As shown in the 2015 NWTT Final EIS/OEIS on Figure 3.4-2 (U.S. Department of the Navy, 2015b), there are three humpback whale feeding areas in U.S. waters in and around the offshore portion of the Study Area. These areas and their seasonal use periods are (1) Point St. George (feeding July to November), (2) Stonewall and Hecta Bank (feeding May–November), and (3) Northern Washington (feeding May–November). Each of these areas is primarily used annually during the approximate six-to-seven-month period when humpback whale feeding occurs at those locations. Specifically for the Northern Washington feeding area, shipboard surveys in July 2005 that included both U.S. and Canadian waters found that humpback whale sightings were concentrated around the edge of what appears to be the semi-permanent eddy associated with the outflow from the Strait of Juan de Fuca (Dalla-Rosa et al., 2012), north of the designated feeding area boundary. The majority of this semi-permanent eddy and associated feeding area is contiguous with the designated

biologically important feeding area, but the northern boundary of the designated feeding area has been drawn as the line between the U.S. and Canadian EEZs. The designated biologically important area was bounded to the north by Canadian waters because the identification of biologically important areas was restricted to only in U.S. waters (Calambokidis et al., 2015; Ferguson et al., 2015b). In addition to feeding areas in Canada, including the inland fjords and Johnstone Strait (Ashe et al., 2013; Best et al., 2015; Ford et al., 2010; Keen et al., 2018), there are consistent concentrated feeding areas in Canadian waters offshore of British Columbia, including off Haida Gwaii, on the continental shelf break between Cape St. James and Cape Scott at Vancouver Island, at the mouth of the Strait of Juan de Fuca, and between Southeast Alaska and Canada at Dixon Entrance (Best et al., 2015; Dalla-Rosa et al., 2012; Ford et al., 2010).

Analyses of Navy training and testing activities in relation to these biologically important feeding areas for humpback whales were previously completed in the 2015 NWTT Final EIS/OEIS (U.S. Department of the Navy, 2015b), evaluated by NMFS in the issuance of the current Letters of Authorization pursuant to the MMPA (National Oceanic and Atmospheric Administration, 2015b), and reviewed by NMFS pursuant to ESA for listed species in the Study Area (National Marine Fisheries Service, 2014).There is no new applicable science that necessitates any changes in those previous analyses. For additional details regarding the analyses, see Section 3.4.2.1 (Acoustic Stressors) and Appendix K (Geographic Mitigation Assessment) in the NWTT Draft Supplemental EIS/OEIS.

Offshore. Humpback whales are expected to be present in the Offshore portion of the Study Area year round. The pattern of increasing humpback whale abundance indicated by previous investigations (Barlow et al., 2011; Calambokidis & Barlow, 2004, 2013; Calambokidis et al., 2017a) appears consistent, with the highest-yet abundances of these species in 2014 (Barlow 2016). Acoustic monitoring over a number of years has demonstrated an overwintering presence of humpback whales and suggests that some portion of the humpback whale population off Washington remain in temperate waters during the winter (Debich et al., 2014; Kerosky et al., 2013; Oleson & Hildebrand, 2012; Širović et al., 2012; Trickey et al., 2015). Satellite tag location data from humpback whales within the Offshore portion of the NWTT Study Area indicate a preference for shallow waters (>200 m depth) consistent with generally known patterns of humpback whale distribution along the Pacific coast (Barlow et al., 2011; Becker et al., 2017; Campbell et al., 2015; Ford et al., 2010; Forney & Barlow, 1998; Mate et al., 2017; U.S. Department of the Navy, 2018a). Five humpback whales have been tracked in the NWTT Study Area using satellite tags (Mate et al., 2017; U.S. Department of the Navy, 2018a). One humpback whale tagged in the waters north of Monterey, California, was tracked for 85 days moving more than 900 km to waters offshore of Pacific City, Oregon (U.S. Department of the Navy, 2018a). While heading north, this individual took an offshore route as far as 200 km from shore and then returned south along a more inshore route. This whale and two others (one tagged off of Newport, Oregon, and the other off Astoria, Oregon) spent portions of time in nearshore shallow waters (less than 200 m in depth) or in Canadian waters, during which they were outside of the NWTT Study Area and the locations where Navy training and testing activities occur (Mate et al., 2017; U.S. Department of the Navy, 2018a). The remaining two of the five tracked humpback whales were tagged near Cape Blanco in southern Oregon and spent most of their time beyond the NWTT Study Area in continental shelf waters off Trinidad Head and Eureka, California (U.S. Department of the Navy, 2017e).

Inland Waters. Data indicate that an increasing number of humpback whales are seasonally present in the Inland Waters portion of the Study Area and that this trend escalated in 2014 (Cascadia Research, 2017a). Based on opportunistic and informal sighting reports in 2015, it was estimated that there were

as many as 15–25 whales present in the Inland Waters portion of the Study Area during any given day (Cogan, 2015).

Western Behm Canal, Alaska. Humpback whales are present in Behm Canal and in summer, relatively high densities of humpback whales occur throughout much of Southeast Alaska (Muto et al., 2017) and northern British Columbia (Ashe et al., 2013; Best et al., 2015; Ford et al., 2010; Keen et al., 2018), and they were observed frequently during spring through fall in a series of surveys from 1991 to 2007 in Southeast Alaska (Dahlheim et al., 2009). Although surveys have not been conducted in the winter months in southeast Alaska, humpback whales have been seen during the winter in Lynn Canal, indicating that some of these animals do not migrate south and remain in Southeast Alaskan waters to feed on herring (Moran et al., 2009). The Navy assumes humpback whales may be present in Behm Canal in all seasons.

4.1.4.3 Population and Abundance

Although there is no site-specific data for Behm Canal, increasing local observations of humpback whales within Behm Canal is consistent with the increasing Central North Pacific stock (Barlow et al., 2011; Bettridge et al., 2015; National Marine Fisheries Service, 2016b; Wade et al., 2016). From the increasing California, Oregon, Washington stock (Carretta et al., 2017c), it is reasonable to assume that the abundance of humpback whales in Southeast Alaska is increasing (Muto et al., 2017).

In inland waters of Washington including the Strait of Juan de Fuca, Puget Sound, and other parts of the Salish Sea, scientists have noted a trend of increased humpback whale abundance (Cascadia Research, 2017a; Cogan, 2015). This is consistent with the pattern of increasing humpback whale abundance in the Pacific, as suggested by data from previous years (Barlow et al., 2011; Calambokidis & Barlow, 2013) and with the highest-yet abundance for the California, Oregon, Washington stock of humpback whale as observed in the NMFS 2014 survey of the U.S. West Coast (Barlow, 2016). For the Offshore and Inland Waters portion of the Study Area and based on surveys from 1991 to 2014, the abundance for humpback whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 834 animals (Barlow, 2016).

4.1.5 Minke Whale (*Balaenoptera acutorostrata*)

4.1.5.1 Status and Management

Minke whales are not considered a threatened or endangered species under the ESA, and neither stock of minke whales in the Study Area is considered depleted under the MMPA. Minke whales in the Behm Canal portion of the Study Area belong to the Alaska stock (Muto et al., 2017), and those in the Offshore and Inland Waters portion belong to the California, Oregon, Washington stock (Carretta et al., 2017c).

4.1.5.2 Geographic Range and Distribution

Minke whales have a predominant nearshore distribution along the coast of North America (Hamilton et al., 2009). In the eastern North Pacific Ocean including the Study Area, year-round observations over multiple years have only visually detected minke whales between March and November (Adams et al., 2014; Cogan, 2015; Debich et al., 2014; Oleson et al., 2009; Smultea et al., 2017; Towers et al., 2013). This occurrence pattern along with other ecological evidence indicates seasonal migrations to warmer waters during the winter season (Towers et al., 2013). Because there have been sightings of individual minke whales in the Inland Waters portion of the Study Area during winter (December and January) in

years past (Everitt et al., 1980), it is conservatively assumed that minke whale are present in the Study Area year round.

In the Behm Canal and Offshore portions of the Study Area, most minke whales are believed to be in constant movement while foraging, given the findings from a 7-year study of the population present at Johnstone Strait (north of Vancouver Island) (Dorsey et al., 1990). In contrast, minke whales around the San Juan Islands in the inland waters of Washington appear to frequent specific home ranges where animals mill about and feed over periods of hours (Dorsey, 1983; Dorsey et al., 1990; Muto et al., 2017; Towers et al., 2013). Photo-identification of individual minke whales has indicated intra-annual movements in excess of approximately 400 km between feeding areas in the coastal waters of northern British Columbia to the inland waters of Washington (Towers et al., 2013).

Offshore. Minke whales are expected to seasonally be present, but minke whale vocalizations have only been detected in passive acoustic monitoring twice in the Offshore portion of the Study Area, in November 2012 and April 2013 (Debich et al., 2014). Minke whale vocalizations have been absent from all other monitoring periods (Kerosky et al., 2013; Širović et al., 2012; Trickey et al., 2015). Minke whales are relatively infrequently visually detected in the region (Barlow, 2016; Oleson et al., 2009; Williams & Thomas, 2007). During NMFS systematic shipboard surveys of the region, minke whales have been encountered offshore Washington as lone individuals totaling six in 1996, two in 2001, and two in 2014 (Barlow, 2016). During aerial surveys in 2011 and 2012 there were six sightings in summer and fall over the Oregon shelf waters portion of the Study Area (Adams et al., 2014). For purposes of the analysis in this Request for LOAs, minke whales offshore are considered to have a regular presence.

Inland Waters. Based on the record of opportunistic marine mammal sightings in the Inland Waters portion of the Study Area (Everitt et al., 1980; U.S. Department of the Navy, 2017f), minke whales have been generally observed as lone individuals, with the exception of larger groups occasionally observed in the Strait of Juan de Fuca and in the vicinity of the San Juan Islands (Cogan, 2015; Dorsey et al., 1990; Smultea et al., 2017; Towers et al., 2013). For purposes of the analysis in this Request for LOAs, minke whales in the Inland Waters portion of the Study Area are considered to have a regular presence.

Western Behm Canal, Alaska. Minke whales were observed infrequently during the spring through fall 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al., 2009). Although surveys have not been conducted in the winter months in southeast Alaska, it is possible that minke whales may be present in the winter, and that is assumed to be the case for this analysis. For purposes of the analysis in this Request for LOAs, minke whales in the Behm Canal portion of the Study Area are considered to have a regular presence.

4.1.5.3 Population and Abundance

There is no estimate of minke whale abundance in the Behm Canal, as this area has not been surveyed (Muto et al., 2017). For the Offshore and Inland Waters portion of the Study Area and based on surveys from 1996 to 2014, the abundance for minke whales in the area (the combined Oregon/Washington stratum and the Northern California stratum; coefficient of variation >1.0) is estimated at 506 animals (Barlow, 2016).

4.1.6 NORTH PACIFIC RIGHT WHALE (*EUBALAENA JAPONICA*)

4.1.6.1 Status and Management

North Pacific right whales are listed as endangered under the ESA, and this species is currently one of the most endangered whales in the world (Clapham, 2016; National Marine Fisheries Service, 2013b, 2017b; Wade et al., 2010). Critical habitat for the North Pacific right whale is located in the western Gulf of Alaska off Kodiak Island and in the southeastern Bering Sea/Bristol Bay area (Muto et al., 2017; Muto et al., 2018b); there is no designated critical habitat for this species within the Study Area. In the Alaska SAR, NMFS provides information for a single stock of North Pacific right whale designated as the Eastern North Pacific stock, although they also recognize a Western North Pacific stock that feeds east of Sakhalin Island (Muto et al., 2017; Muto et al., 2018b).

4.1.6.2 Geographic Range and Distribution

Until recently, historical whaling records provided virtually the only information on North Pacific right whale distribution (Gregr et al., 2000; National Marine Fisheries Service, 2013b; Wright et al., In press). This species historically occurred across the Pacific Ocean north of 35° N, with concentrations in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Okhotsk Sea, and the Sea of Japan (Gregr et al., 2000; Ivashchenko & Chapham, 2012; Scarff, 1991, 2001; Shelden et al., 2005). Right whales were probably never common along the west coast of North America (Brownell et al., 2001; Reeves & Smith, 2010; Scammon, 1874; Scarff, 1991, 2001). They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (National Marine Fisheries Service, 2013b, 2017b). In recent years, this species has generally only been observed or acoustically detected in the Bering Sea/Bristol Bay Alaska area (Brownell et al., 2001; Shelden et al., 2005; U.S. Department of the Navy, 2017c; Wade et al., 2010; Wade et al., 2011; Wright et al., In press; Zerbini et al., 2010; Zerbini et al., 2015),with occasional sightings in the western Gulf of Alaska area (Matsuoka et al., 2014; Širović et al., 2015a; U.S. Department of the Navy, 2017c; Wade et al., 2011).

Offshore. The likelihood of an individual Eastern North Pacific right whale being present in the NWTT Study Area is extremely low given that they have rarely being detected south of the waters around Kodiak Alaska, and there is no evidence to suggest that the western coast of the United States was ever highly frequented by this species (Brownell et al., 2001; Reeves & Smith, 2010; Scammon, 1874). As presented in the 2015 NWTT Final EIS/OEIS (U.S. Department of the Navy, 2015b), there have been a few detections of right whales south of Alaska waters in the eastern Pacific in modern times. In June 2013 a single right whale was sighted in the waters off Haida Gwaii. Approximately nine days later and 200 NM to the south, a Navy-funded bottom-mounted passive acoustic monitoring device at Quinault Canyon detected two right whale calls within a two-hour period (Širović et al., 2015a). In October 2013 off the Strait of Juan de Fuca, another (different) single right whale was seen with a group of humpback whales moving south into the Offshore portion of the Study Area (U.S. Department of the Navy, 2015b). There have also been four sightings, each of a single right whale, in California waters within approximately the last 30 years (in 1988, 1990, 1992, and 2017) (Brownell et al., 2001; Carretta et al., 1994; Price, 2017). In 2017, a lone right whale was briefly observed close to shore off La Jolla Cove in Southern California (Price, 2017), and it is reasonable to assume that this individual and others sighted in California traveled through the Study Area on their way to and from Arctic waters. Based on this data, vagrant individual North Pacific right whales are not expected to be present in the NWTT Study Area. If ever present, they are unlikely remain for more than a few days and therefore are not likely to be present contemporaneous in time or in the vicinity of Navy training and testing activities occurring

offshore. As a result, North Pacific right whales are extremely unlikely to be exposed to stressors associated with Navy training and testing activities.

Inland Waters. The rarity of the species and the historical occurrence patterns suggest that right whales would not be present in inland water areas. The occurrence of a North Pacific right whale within the Inland Waters portion of Study Area is considered extralimital.

Western Behm Canal, Alaska. There is no evidence of North Pacific right whale occurrence in waters to the east of the Pacific coast. Given the rarity of the species and the historic occurrence patterns, North Pacific right whales are considered extralimital within the Behm Canal portion of Study Area.

4.1.6.3 Population and Abundance

The most recent abundance estimate for the eastern North Pacific right whale is between 26 and 31 individuals in the population (Muto et al., 2017). Although this estimate may be reflective of a Bering Sea subpopulation, the total eastern North Pacific population is unlikely to be much larger (Muto et al., 2017; Wade et al., 2010). In the North Pacific west of the International Date Line, Matsuoka et al. (2014) documented as many as 55 North Pacific right whale sightings (77 animals) between 1994 and 2013. The stock from which these individuals belong has not been identified, but for purposes of this analysis they are assumed to belong to the stock of Western North Pacific right whales.

4.1.7 Sei Whale (*Balaenoptera borealis*)

4.1.7.1 Status and Management

The sei whale is listed as an endangered under the ESA, but there is no designated critical habitat for this species (Carretta et al., 2017c; Carretta et al., 2018b). A single Eastern North Pacific stock is recognized in the U.S. EEZ and considered depleted under the MMPA (Carretta et al., 2017c; Carretta et al., 2018b).

4.1.7.2 Geographic Range and Distribution

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes across the North Pacific where there is steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best & Lockyer, 2002; Gregr & Trites, 2001; Horwood, 1987; Horwood, 2009). Sei whales are migratory, spending the summer months feeding in the subpolar higher latitudes and returning to the lower latitudes to calve in the winter (Fulling et al., 2011; Horwood, 1987; Horwood, 2009; Olsen et al., 2009; Rone et al., 2017; Smultea, 2014; Smultea et al., 2010). In the winter in the Pacific, sei whales have been detected as far south as the Mariana Islands, Hawaii, and Southern California (Fulling et al., 2011; Smultea, 2014; Smultea et al., 2010). Analysis of sei whale genetic samples from around the Pacific suggests a single stock present in the Pacific ((Baker et al., 2006; Huijser et al., 2018).

Offshore. Sei whales are expected to be present in the Offshore portion of the Study Area (Barlow, 2016; Williams & Thomas, 2007).

Inland Waters. There are no records of sei whales being sighted or otherwise present in the Inland Waters potion of the Study Area (Gregr et al., 2006; U.S. Department of the Navy, 2017f).

Western Behm Canal, Alaska. There are no data to indicate that sei whales ever venture from the Pacific into areas like Behm Canal (see Dahlheim et al. (2009)); the species is not included in the Alaska SAR (Muto et al., 2017).

4.1.7.3 Population and Abundance

There is no estimate of an abundance for sei whales in the Behm Canal given there is no indication that the species is present in the area (Dahlheim et al., 2009); the species is not included in the Alaska SAR (Muto et al., 2017).

There has been an increase in sei whales off the Washington and Oregon coast in recent years, with more groups of sei whales sighted in 2014 than in all previous NMFS surveys combined (Barlow, 2016). For the Offshore portion of the Study Area and based on surveys from 1991 to 2014, the abundance of sei whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 212 animals (Barlow, 2016).

4.2 ODONTOCETES

4.2.1 BAIRD'S BEAKED WHALE (*BERARDIUS BAIRDII*)

4.2.1.1 Status and Management

Baird's beaked whale is not listed under the ESA. Baird's beaked whale is managed by NMFS within Pacific U.S. EEZ waters as two stocks: (1) an Alaska stock; and (2) a California, Oregon, and Washington stock. These stocks are not considered depleted under the MMPA (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017; Muto et al., 2018b).

4.2.1.2 Geographic Range and Distribution

This species is generally found through the colder waters of the North Pacific north of 28° N, ranging from waters off Baja California, Mexico, to the Aleutian Islands of Alaska (Jefferson et al., 2015; Kasuya & Miyashita, 1997; MacLeod et al., 2006; Reeves et al., 2002). Within their range, Baird's beaked whale occurs mainly in deep waters over the continental slope, near oceanic seamounts, and areas with submarine escarpments, although they may be seen close to shore where deep water approaches the coast (Jefferson et al., 2015; Kasuya, 2009). Off Washington and British Columbia, Baird's beaked whales have been sighted in offshore waters with bottom depths of 700–1,675 m (Willis & Baird, 1998b). Based on habitat models derived from line-transect survey data collected between 1991 and 2008 off the U.S. West Coast, encounters with Baird's beaked whales increase near the 2,000 m isobath and further offshore in waters off Washington and Oregon (Barlow, 2016; Becker et al., 2012b).

Offshore. NMFS surveys have consistently revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow, 2003, 2010, 2016).

Acoustic analyses of data collected from Navy-funded monitoring devices in Washington offshore waters have routinely detected Baird's beaked whale vocalizations (Debich et al., 2014; Kerosky et al., 2013; Širović et al., 2012; Trickey et al., 2015). There has, however, been variability for the timing of these detections; they occurred between January and November 2011, with a peak in detections in February and July (Širović et al. 2012b); from October through December 2012, and May 2013 (Debich et al., 2014; Kerosky et al., 2013); and from August 2013 through January 2014, with an additional single encounter in March 2014 (Trickey et al., 2015). During aerial surveys conducted in waters off Washington, Oregon, and Northern California covering the approximate nearshore half of the Study

Area in the spring, summer, and fall of 2011 and 2012, there was a sighting of a Baird's beaked whale group consisting of 10 individuals (Adams et al., 2014), and five group sightings during the 2014 NMFS survey with the same approximate average group size (Barlow, 2016). For purposes of the analysis in this Request for LOAs, Baird's beaked whales are considered to have a regular presence in the Offshore portion of the Study Area.

Inland Waters. Given their offshore distribution, Baird's beaked whales are not expected to occur within the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. In the North Pacific Ocean and along the U.S. West Coast, Baird's beaked whales are seen primarily along the continental slope in deep waters (Barlow, 2016; Rone et al., 2017). Baird's beaked whales have been sighted in the Gulf of Alaska (Rone et al., 2017) and off the Pacific coast of Southeast Alaska (Hamilton et al., 2009), but were not observed during the 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al., 2009). There is no indication that beaked whales inhabit the Behm Canal portion of the Study Area (Dahlheim et al., 2009; Muto et al., 2017), and they are considered extralimital in this location.

4.2.1.3 Population and Abundance

There is currently no reliable abundance estimate for the Alaska stock of Baird's beaked whale (Muto et al., 2017), which Navy has assumed will not be present in Behm Canal. For the Offshore portion of the Study Area and based on surveys from 1991 to 2014, the abundance for Baird's beaked whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 4,326 animals (Barlow, 2016).

4.2.2 Common Bottlenose Dolphin (*Tursiops truncatus*)

4.2.2.1 Status and Management

The common bottlenose dolphin is not listed under the ESA. For bottlenose dolphins within the Pacific U.S. EEZ there are seven stocks, but only the California, Oregon, and Washington offshore stock is occasionally present in the Offshore portion of the Study Area as part of their recognized range (Carretta et al., 2017c). The California, Oregon, and Washington stock is not considered depleted under the MMPA.

4.2.2.2 Geographic Range and Distribution

Bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world; the primary range of the California, Oregon, and Washington stock is south of approximately 38° N (Carretta et al., 2017c). Based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, very low densities of bottlenose dolphins are predicted north of approximately 40° N during the summer and fall (Becker et al., 2016). Bottlenose dolphins are expected to expand their range north into Oregon and Washington waters during El Niño events, when water temperatures increase in the area (Cascadia Research Collective, 2011). A mixed-species group of approximately 200 bottlenose dolphins and 70 false killer whales was observed 500 km north of the Strait of Juan de Fuca and 180 km off the coast of British Columbia (at approximately 50° N) on 29 July 2017, which was suggested to have been associated with the prolonged period of ocean warming along the Pacific Coast (Halpin et al., 2018).

Offshore. Off the U.S. West Coast, bottlenose dolphins are generally encountered south of approximately 41° N (Adams et al., 2014; Barlow, 2016; Hamilton et al., 2009). In September 2012, a pod of four bottlenose dolphins was encountered during an aerial survey off Grays Harbor (Adams et al., 2014). For purposes of this analysis, bottlenose dolphins are considered to have a regular occurrence in the Offshore portion of the Study Area.

Inland Waters. Bottlenose dolphins are considered extralimital in the Inland Waters portion of the Study Area. Prior to 2017, there had been one bottlenose dolphin stranding and only occasional sightings, generally consisting of lone individuals, within the Salish Sea (Cascadia Research Collective, 2011; National Marine Fisheries Service, 2017a; U.S. Department of the Navy, 2017f). In the fall of 2017, a group of bottlenose dolphins was sighted repeatedly in Puget Sound, which is unusual given the species tends to be found in areas with warmer temperature as opposed to cold-water areas such as the Pacific northwest (Cascadia Research, 2017d). One animal in the group was photo identified as a well-known dolphin first sighted in Southern California in 1983, belonging to the California Coastal stock of bottlenose dolphins, but which the evidence suggests has been part of a group incrementally expanding the northern range of the stock (Cascadia Research, 2017d). The Navy does not expect the temporary presence of these California Coastal stock animals to reflect a permanent expansion northward for these animals and the stock is therefore not included in this request.

Western Behm Canal, Alaska. Given the species preference for warmer water habitat, bottlenose dolphins are not expected to occur within the Behm Canal portion of the Study Area.

4.2.2.3 Population and Abundance

Based on surveys from 1991 to 2008, the abundance for bottlenose dolphins in the Northern California portion of the Study Area is estimated at 253 animals and is 0 for the more northern Oregon/Washington stratum; the species was not detected in the Study Area in 2014 (Barlow, 2016).

4.2.3 Cuvier's Beaked Whale (*Ziphius cavirostris*)

4.2.3.1 Status and Management

Cuvier's beaked whales are not considered a threatened or endangered species under the ESA, and neither of these stocks in the Study Area is considered depleted under the MMPA. Cuvier's beaked whale is managed by NMFS within Pacific U.S. EEZ waters as two stocks: (1) the Alaska stock (Muto et al., 2017); and (2) the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.3.2 Geographic Range and Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Baird et al., 2010; Heyning & Mead, 2009; Jefferson et al., 2015; MacLeod et al., 2006; Schorr et al., 2014). Worldwide, beaked whales normally inhabit both slope and deep oceanic waters with depths greater than 200 m and frequently where depths are greater than 1,000 m (Baird et al., 2010; Jefferson et al., 2015; MacLeod et al., 2006; MacLeod et al., 2003; MacLeod & D'Amico, 2006; Schorr et al., 2014). Research findings for satellite location tagged Cuvier's beaked whales in the Southern California Range Complex (Falcone et al., 2009; Falcone & Schorr, 2011, 2012, 2013, 2014), which is the same stock of animals present in the NWTT Study Area, have documented movements by individuals in excess of hundreds of kilometers. Schorr et al. (2014) reported that five out of eight tagged whales journeyed approximately 250 km from their tag deployment location, and one of these individuals made an excursion of over 450 km to the south of its initial location and then back.

Offshore. Cuvier's beaked whales have been routinely sighted during NMFS surveys in the waters of the Study Area (Barlow, 2016; Hamilton et al., 2009). Offshore of Washington, Cuvier's beaked whales have been acoustically detected in the winter and spring (between mid-November and April) (Debich et al., 2015; Kerosky et al., 2013; Trickey et al., 2015), although they were also detected sporadically in the spring through fall (February–September) in 2011 and 2012 (Kerosky et al., 2013; Širović et al., 2012). The Navy assumes this is indicative of variable year-round presence in the Offshore portion of the Study Area.

Inland Waters. Based on the available information (National Marine Fisheries Service, 2017a; U.S. Department of the Navy, 2017f), beaked whales are not expected to occur within the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. There is no indication that beaked whales inhabit the Behm Canal portion of the Study Area (Dahlheim et al., 2009; Muto et al., 2017), and they are considered extralimital in this location.

4.2.3.3 Population and Abundance

There is currently no reliable abundance estimate for the Alaska stock of Cuvier's beaked whale (Muto et al., 2017), which the Navy assumes will not be present in Behm Canal.

For the Offshore portion of the Study Area and based on surveys from 1991 to 2014, the abundance for Cuvier's beaked whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 1,442 animals (Barlow, 2016).

4.2.4 Dall's Porpoise (*Phocoenoides dalli*)

4.2.4.1 Status and Management

Dall's porpoise are not considered a threatened or endangered species under the ESA, and neither stock in the Study Area is considered depleted under the MMPA. Dall's porpoise in the Behm Canal portion of the Study Area are from the Alaska stock (Muto et al., 2017; Muto et al., 2018b), and those in the Offshore and Inland Waters portion are from the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.4.2 Geographic Range and Distribution

Dall's porpoise is one of the most abundant small cetaceans in the North Pacific Ocean along the outer continental shelf, slope, and oceanic waters where water temperatures are less than 17°C (Barlow, 2016; Becker et al., 2017; Carretta et al., 2017c; Houck & Jefferson, 1999; Jefferson et al., 2015; Reeves et al., 2002; Suzuki et al., 2016). In the eastern north Pacific, the species ranges from Southern California to the Bering Sea. Dall's porpoise distribution off the U.S. West Coast is highly variable between years, most likely due to changes in oceanographic condition, with Dall's porpoise shifting their distribution in response to those changes on both interannual and seasonal time scales (Barlow, 2016; Becker et al., 2010; Becker et al., 2012b; Becker et al., 2017; Carretta et al., 2017c; Forney & Barlow, 1998; Forney et al., 2012; Forney et al., 2015). In the NMFS 2014 survey of the U.S. West Coast, sightings of Dall's porpoise were very low in southern and central California, indicative of a distributional shift to the north in comparison to their previous distribution found during the three surveys undertaken between 2001 and 2008 (Barlow, 2016).

Offshore. Dall's porpoise have been one of the most frequently sighted marine mammal during surveys in waters off Washington, Oregon, and Northern California (Adams et al., 2014; Barlow, 2016; Hamilton et al., 2009; Oleson et al., 2009). In the spring, summer, and fall of 2011 and 2012, Dall's porpoise were most often encountered between the 200 and 2,000 m depth isobaths (Adams et al., 2014). For purposes of the analysis in this Request for LOAs, Dall's porpoise are considered to have a regular presence in the Offshore portion of the Study Area.

Inland Waters. Dall's porpoise used to be present in the inland waters year round with seasonably variable but relatively high estimated abundance (Calambokidis & Baird, 1994). In recent years, Dall's porpoise have been declining in number in the Salish Sea and Puget Sound, and speculation has been that this decline is a result of competition with harbor porpoise, which have dramatically increased in numbers over approximately the last 15 years (Evenson et al., 2016; Jefferson et al., 2016; Smultea et al., 2017). Consistent with this decline, in six aerial surveys of Puget Sound between 2013 and 2016, only a single Dall's porpoise was observed in Hood Canal in April 2015, and a group of eight was observed in Admiralty Inlet in January 2016 (Smultea et al., 2017). Although they have been seen in decreasing numbers in recent years, for purposes of the analysis in this Request for LOAs, Dall's porpoise are considered to have a regular presence in the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. Dall's porpoise was the most frequently observed species during surveys conducted in the inland waters of southeast Alaska between 1991 and 2007 (Dahlheim et al., 2009). Although surveys have not been conducted in the winter months in southeast Alaska, it is possible that Dall's porpoises may be present in the winter season; for purposes of this analysis, the Navy assumes the species is present year round.

4.2.4.3 Population and Abundance

There are no reliable abundance data for the Alaska stock of Dall's porpoise given the most recent data are over 26 years old (Muto et al., 2017; Muto et al., 2018b). The current estimate of abundance provided in the Alaska SAR is 83,400 animals (Muto et al., 2017; Muto et al., 2018b). For the Offshore and Inland Waters portion of the Study Area and based on surveys from 1991 to 2014, the abundance for Dall's porpoise in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 33,073 animals (Barlow, 2016). The most recent NMFS survey in 2014 found Dall's porpoise abundance fairly typical of their abundance in the previous three surveys between 2001 and 2008 (Barlow, 2016).

4.2.5 Dwarf Sperm Whale (*Kogia sima*)

4.2.5.1 Status and Management

Dwarf sperm whales are not considered a threatened or endangered species under the ESA and are not considered depleted under the MMPA. Dwarf sperm whales in the Offshore portion of the Study Area are from the California, Oregon, Washington stock (Carretta et al., 2017c). Along the U.S. West Coast and because of the difficulty distinguishing between dwarf and pygmy sperm whales at sea, identifications during surveys have generally been to *Kogia* spp. as the lowest taxonomic level of identification possible (Barlow, 2016; Carretta et al., 2017c; Hamilton et al., 2009). As a result, metrics for the population in the stock assessments for U.S. West Coast have been to *Kogia* spp. (Carretta et al., 2017c).

4.2.5.2 Geographic Range and Distribution

There has only been one sighting identified as *Kogia* spp. north of California on any of the survey efforts between 1991 and 2014 (Barlow, 2016; Hamilton et al., 2009). Along the U.S. West Coast, no reported sightings of this species have been confirmed as dwarf sperm whales, and it is likely that most Kogia species off California are pygmy sperm whale (*Kogia breviceps*) (Carretta et al., 2017c). There is record of a single dwarf sperm whale stranding at Vancouver Island British Columbia (Willis & Baird, 1998a) and one stranded unidentified *Kogia* spp. in Washington in 2007 (National Marine Fisheries Service, 2017a).

Offshore. Dwarf sperm whales are expected to be rare in the Offshore portion of the Study Area.

Inland Waters. Dwarf sperm whales are not expected to occur within the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. Dwarf sperm whales are not expected to occur within the Behm Canal portion of the Study Area.

4.2.5.3 Population and Abundance

For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance for *Kogia* spp. in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 766 animals (Barlow, 2016).

4.2.6 Harbor Porpoise (*Phocoena phocena*)

4.2.6.1 Status and Management

Harbor porpoise are not considered a threatened or endangered species under the ESA. Harbor porpoise in the Behm Canal portion of the Study Area belong to the Southeast Alaska stock, which spans an area of approximately 500 NM in length from Dixon Entrance in the south to Cape Suckling in the north (Muto et al., 2017; Muto et al., 2018b). Studies of harbor porpoise distribution elsewhere have indicated that this stock structure is likely more fine-scaled than is reflected in the current Alaska SAR, but no data are available to more precisely define the stock structure for harbor porpoise in Alaska (Muto et al., 2017; Muto et al., 2018b). In the Offshore portion of the Study Area, there are two stocks: the Northern Oregon/Washington Coast stock and the Northern California/Southern Oregon stock (Carretta et al., 2017c). In the Inland Waters portion of the Study Area harbor porpoise belong to the Washington Inland Waters stock (Carretta et al., 2017c). None of the stocks of harbor porpoise in the Study Area are considered depleted under the MMPA.

4.2.6.2 Geographic Range and Distribution

In the eastern North Pacific from Alaska south to Point Conception, California, harbor porpoise are found in nearshore coastal and inland waters, generally within a mile or two of shore (Barlow, 1988; Carretta et al., 2015; Carretta et al., 2017c; Dahlheim et al., 2015; Dohl et al., 1983; Hamilton et al., 2009; Muto et al., 2017). As noted previously, there is evidence for the redistribution of local harbor porpoise to and from other areas in response to what are likely local fluctuations in prey availability, habitat suitability, or other unidentified factors (Dahlheim et al., 2015; Evenson et al., 2016; Jefferson et al., 2016; Muto et al., 2017; Smultea et al., 2015; Smultea et al., 2017).

Offshore. In aerial surveys conducted in waters off Washington, Oregon, and Northern California covering the approximate nearshore half of the Study Area in the spring, summer, and fall of 2011 and 2012, harbor porpoise were the most frequently sighted marine mammal (Adams et al., 2014). Harbor porpoise are expected to be present in the Offshore portion of the Study Area year round.

Inland Waters. Based on surveys in the Salish Sea and Puget Sound (Elliser et al., 2017; Evenson et al., 2016; Jefferson et al., 2016; Smultea et al., 2017), harbor porpoise are expected to be present in the Inland Waters portion of the Study Area year round. Calves are more likely to be seen in fall, which surveys off Fidalgo Island from January 2014 to February 2017 indicated was also when the highest number of sightings per unit of survey effort were present (Elliser et al., 2017).

Western Behm Canal, Alaska. Although surveys have not occurred in Southeast Alaska in the winter (Dahlheim et al., 2009; Dahlheim et al., 2015), for purposes of this analysis the Navy assumes harbor porpoise will be present in the Behm Canal portion of the Study Area year round.

4.2.6.3 Population and Abundance

In surveys conducted over approximately 20 years in Southeast Alaska, the overall abundance of harbor porpoise in the Ketchikan region (including Behm Canal) significantly declined from the early 1990s to the mid-2000s, followed by a significant increase in the early 2010s when abundance rose to levels similar to those observed 20 years earlier (Dahlheim et al., 2015). It is not clear whether the observed decline and subsequent increase in abundance noted in the Ketchikan region was a true change in the stock abundance or if the decline and subsequent increase reflected the redistribution of local harbor porpoise to and from other areas in response to local fluctuations in prey availability, habitat suitability, or other unidentified factors (Dahlheim et al., 2015; Muto et al., 2017). The Alaska SAR divides the estimates of abundance for the Southeast Alaska stock of harbor porpoise into a northern and a southern region including Frederick Sound, Sumner Strait, Wrangell and Zarembo Islands, and Clarence Strait as far south as Ketchikan, with an abundance of 577 animals in that southern region (Muto et al., 2017).

In the Offshore portion of the Study Area, the abundance of the Northern Oregon/Washington Coast stock is 21,487 and the Northern California/Southern Oregon stock is 35,769 (Carretta et al., 2017c). In the Inland Waters portion of the Study Area the abundance of the Washington Inland Waters stock is 11,233 (Carretta et al., 2017c). Evenson et al. (2016) determined that the annual growth rate for harbor porpoise between 1995 and 2014 was 8.1 percent for the Strait of Juan de Fuca region, and the annual growth rate between 2000 and 2014 was 36.9 percent for Puget Sound. Aerial surveys between 2013 and 2015 have demonstrated that since the 1970s, harbor porpoises have recovered and reoccupied waters of Puget Sound (Jefferson et al., 2016).

4.2.7 KILLER WHALE (*ORCINUS ORCA*)

4.2.7.1 Status and Management

For the populations of killer whales present in the Study Area, only the Southern Resident population is listed as endangered under the ESA; the remaining populations are not listed under the ESA (Carretta et al., 2018b; Muto et al., 2018b). NMFS designated critical habitat for Southern Resident killer whales totals 2,560 mi.^{2} and includes Haro Strait and the waters around the San Juan Islands, Puget Sound, and the Strait of Juan de Fuca, but does not include any of Hood Canal or locations where the water depth is less than 20 ft. (National Marine Fisheries Service, 2016e; National Marine Fisheries Service: Northwest

Region, 2006; National Oceanic and Atmospheric Administration, 2014). Eighteen sites[4] owned or controlled by the Department of Defense are excluded from this critical habitat designation, including Navy installations within Puget Sound. The NMFS identified primary constituent elements essential for conservation of the Southern Resident killer whale critical habitat as (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (National Marine Fisheries Service: Northwest Region, 2006). There have been concerns over impacts on Southern Resident killer whales in this critical habitat resulting from whale-watching vessel disturbance (Ferrara et al., 2017; Holt et al., 2017; Lacy et al., 2017; National Marine Fisheries Service, 2016e, 2018a; Seely et al., 2017), commercial shipping noise (Veirs et al., 2016; Williams et al., 2019), and prey availability (Shields et al., 2018b; Wasser et al., 2017). In 2014, NMFS received a petition to revise the existing Southern Resident killer whale critical habitat (National Oceanic and Atmospheric Administration, 2014). NMFS found the revision may be warranted given tag data demonstrating the species also spends considerable time outside the inland waters of the Pacific Northwest while inhabiting nearshore areas along the Washington/Oregon/California coastline (National Oceanic and Atmospheric Administration, 2014). A review of the currently designated critical habitat by NMFS, to determine whether the areas designated for this species need to be revised, is still underway as of August 2018, although NMFS had previously anticipated developing a proposed rule for publication in the Federal Register sometime in 2017 (80 FR 9682; February 24, 2015). The use of the Inland portion of the NWTT Study Area by Southern Resident killer whales, including their critical habitat, has declined in recent years as they shift their range and forage for Chinook salmon or other prey species elsewhere in response to prey availability (Shields et al., 2018b).

Seven killer whale stocks are recognized in the Eastern North Pacific: (1) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock (Prince William Sound through the Aleutian Islands and Bering Sea); (2) the AT1 Transient stock (Alaska from Prince William Sound through the Kenai Fjords); (3) the Eastern North Pacific Alaska resident stock (southeastern Alaska to the Aleutian Islands and Bering Sea); (4) the Eastern North Pacific Northern Resident stock (Washington State through part of southeastern Alaska); (5) the West Coast Transient stock (Alaska through California); (6) the Eastern North Pacific Offshore stock (southeast Alaska through California); and (7) the Eastern North Pacific Southern Resident stock (mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeast Alaska through California) (Carretta et al., 2017c; Muto et al., 2017). As shown in the NMFS SARs, out of these seven stocks there are five (Alaska Resident, Northern Resident, West Coast Transient, Offshore, and Southern Resident stocks) that may be present in the Study Area. Out of those five stocks, only the Southern Resident stock is considered depleted under the MMPA (Carretta et al., 2017c; Muto et al., 2017).

[4] These 18 sites as provided in the final rule establishing the critical habitat consist of the following: (1) Naval Undersea Warfare Center, Keyport; (2) Naval Ordnance Center, Port Hadlock (Indian Island); (3) Naval Fuel Depot, Manchester; (4) Naval Air Station, Whidbey Island; (5) Naval Station Everett; (6) Naval Hospital Bremerton; (7) Fort Lewis (Army); (8) Pier 23 (Army); (9) Puget Sound Naval Ship Yard; (10) Strait of Juan de Fuca naval air-to-surface weapon range, restricted area; (11) Strait of Juan de Fuca and Whidbey Island naval restricted areas; (12) Admiralty Inlet naval restricted area; (13) Port Gardner Naval Base restricted area; (14) Port Orchard Passage naval restricted area; (15) Sinclair Inlet naval restricted area; (16) Carr Inlet naval restricted area; (17) Port Townsend/Indian Island/Walan Point naval restricted area; and (18) Crescent Harbor Explosive Ordnance Units Training Area.

4.2.7.2 Geographic Range and Distribution

Killer whales are found in all marine habitats from the coastal zone, including most bays and inshore channels, to the deep ocean and from equatorial regions to the polar pack ice zones of both hemispheres (Dahlheim et al., 2008; Forney & Wade, 2006; Garcia et al., 2016; Hanson et al., 2017; Wiles, 2016). Some killer whales such as the Southern Residents have seasonal shifts in distribution from the inland waters of the Salish Sea and Puget Sound to locations that can be up to hundreds of miles both north or south of the Study Area (Cogan, 2015; Dahlheim et al., 2008; Ford et al., 2014; Hanson et al., 2015; Houghton et al., 2015; National Marine Fisheries Service, 2016e; National Oceanic and Atmospheric Administration, 2011; National Oceanic and Atmospheric Administration Fisheries, 2014; Rice et al., 2017). The K1 and L1 pods have been sighted as far south as Monterey Bay and central California in recent years (Carretta et al., 2018a).

Distributions of killer whales are somewhat associated with the killer whale ecotypes, and all three ecotypes (offshore, transients, and residents) are known to occur in the Study Area (Carretta et al., 2017c; Cogan, 2015; Debich et al., 2014; Ford et al., 2013; Ford et al., 2014; Hanson et al., 2017; Kerosky et al., 2013; Muto et al., 2017; National Marine Fisheries Service, 2016e; National Marine Fisheries Service: Northwest Region, 2006; Oleson et al., 2009; Oleson & Hildebrand, 2012; Rice et al., 2017; Širović et al., 2012; Trickey et al., 2015; Wiles, 2016).

Offshore. In the Offshore portion of the Study Area, there are variable seasonal distributions for all three killer whale ecotypes and associated stocks, which overlap in many cases. Details regarding these distributions, the seasonal variation, and overlap within sub-areas are presented in the NWTT Marine Species Density Database Technical Report (U.S. Department of the Navy, 2019a). In summary, for the offshore area the stocks present may include the Offshore, West Coast Transient, Northern Resident, and Southern Resident stocks, depending on the season and the distance from shore (Debich et al., 2014; Fisheries and Oceans Canada, 2015; Ford et al., 2013; Ford et al., 2014; Hanson et al., 2017; Kerosky et al., 2013; National Marine Fisheries Service, 2016e; National Marine Fisheries Service: Northwest Region, 2006; Oleson et al., 2009; Oleson & Hildebrand, 2012; Rice et al., 2017; Širović et al., 2012; Trickey et al., 2015; Wiles, 2016).

To better predict the pattern of distribution of the endangered Southern Resident killer whales off the Washington, Oregon, and Northern California coasts, researchers integrated visual sightings, location data obtained between 2012 and 2016 from satellite-tagged Southern Resident killer whales, and acoustic detections from underwater hydrophones obtained from 6 to 13 recorders deployed from 2011 to 2015 off the Washington, Oregon, and California coast (Hanson et al., 2018; U.S. Department of the Navy, 2018a). Along the Pacific coast, the distribution of satellite-tag locations confirms that Southern Resident killer whales generally inhabit nearshore waters and over multiple years have spent the highest amount of time near the mouth of the Columbia River and Westport, Washington (Hanson et al., 2017; Hanson et al., 2018; U.S. Department of the Navy, 2018a). Southern Resident killer whales were also acoustically detected by the monitoring hydrophones as far as 62 km off Cape Flattery, at the northern extreme of the NWTT Study Area off Washington (Hanson et al., 2018; U.S. Department of the Navy, 2018a), which is also the area where there appears to be the semi-permanent and highly productive eddy associated with the outflow from the Strait of Juan de Fuca (Dalla-Rosa et al., 2012; MacFadyen et al., 2008).

Inland Waters. The stocks present in the Inland Waters portion of the Study Area may include the West Coast Transient, Northern Resident, and Southern Resident stocks depending on the season and the

sub-area within the inland waters (Cogan, 2015; Ford et al., 2013; Ford et al., 2014; Hanson et al., 2017; National Marine Fisheries Service, 2016e; National Marine Fisheries Service: Northwest Region, 2006; Smultea et al., 2017; Wiles, 2016). Details regarding these distributions, the seasonal variation, and overlap within sub-areas of the inland waters were provided in the 2015 NWTT Final EIS/OEIS and are incorporated as appropriate into the NWTT Marine Species Density Database Technical Report(U.S. Department of the Navy, 2019a). A summary and supplemental update of the discussion from the 2015 NWTT Final EIS/OEIS is provided in the paragraphs below using updated references not available at the time.

Transient killer whales in the Pacific Northwest spend most of their time along the outer coast of British Columbia and Washington, but they visit inland waters in search of harbor seals, sea lions, and other prey (Cogan, 2015; Ford & Ellis, 1999; Ford et al., 2013; Rice et al., 2017; Wiles, 2016). Transients may occur in inland waters in any month (Cogan, 2015; Ford et al., 2013; Kriete, 2007; Rice et al., 2017). The number of West Coast Transient killer whale occurrences inside marine waters increased between 1987 and 2010, possibly because the abundance of some prey species (e.g., seals, sea lions, and porpoises) had increased (Houghton et al., 2015). Over the last 14 years, transient killer whale numbers in the Salish Sea have continued to increase, with 2017 having the record as the most sightings in a single year (Shields et al., 2018a).

Individuals of the Northern Resident stock are occasionally present in the Strait of San Juan de Fuca Inland Waters portion of the Study Area (Cogan, 2015; Wiles, 2016; Wright et al., 2017b).

The Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters (Carretta et al., 2017d; National Marine Fisheries Service, 2016e). Photo-identification of individual whales through the years has resulted in a substantial understanding of this stock's structure, behaviors, and movements in inland waters (Wiles, 2016; Wright et al., 2017b). In spring and summer months, the Southern Resident stock is most frequently seen in the San Juan Islands region with intermittent sightings in Puget Sound (Olson & Osborne, 2017; Shields et al., 2018b), which is consistent with the "summer core area" identified during the establishment of the critical habitat for the species. In the fall and early winter months, the Southern Residents are seen more frequently in Puget Sound, where returning chum and Chinook salmon are concentrated. By winter, they spend progressively less time in the inland marine waters and more time off the coast of Washington, Oregon, and California (Black, 2011; Cogan, 2015; Hanson et al., 2017; National Marine Fisheries Service, 2016e; Olson & Osborne, 2017). As noted previously, the use of the Inland portion of the NWTT Study Area by Southern Resident killer whales has declined in recent years as they shift their range in response to prey availability in Puget Sound (Shields et al., 2018b).

While both Southern Resident killer whales and transient killer whales are frequently sighted in the main basin of Puget Sound, their presence near Navy installations varies from not present at all to infrequent sightings, depending on the season (Olson & Osborne, 2017). As was detailed in the 2015 NWTT Final EIS/OEIS, Section 3.4.2.15.3 (Distribution), Southern Resident killer whales have not been reported in Hood Canal or Dabob Bay since 1995; transient killer whales were last observed in Hood Canal in 2003 and 2005 (National Marine Fisheries Service: Northwest Region, 2006), but there were no reports of subsequent visits to those waters until May 2018 (Seattle Times 2018). Near NAVBASE Kitsap Bremerton and Keyport, the Southern Resident killer whale is also rare, with the last confirmed sighting in Dyes Inlet in 1997 (Navy has assumed Transients will occasionally be present in these areas). Both Southern Resident killer whales and transients have been observed in Saratoga Passage and Possession Sound

near NASWI and Naval Station Everett, respectively. Transients and Southern Resident killer whales have also been observed in southern Puget Sound in the Carr Inlet area.

Western Behm Canal, Alaska. In Southeast Alaska including the Behm Canal, the Alaska Resident, Offshore, and Transient stock ecotypes are present based on the assigned stocks in the Alaska SAR (Dahlheim et al., 2009; Muto et al., 2017). Killer whales from the Transient stock are considered rare in the Behm Canal region of the Study Area (Dahlheim et al., 2009). Northern Resident killer whales have been documented in southeast Alaska, although in the summer they are found primarily in central and northern British Columbia (Muto et al., 2017). Therefore, individuals belonging to the Alaska Resident stock are the killer whales most likely to occur in the SEAFAC region of the Study Area, and are more likely from spring through fall (Dahlheim et al., 2009). Southern Resident killer whales (L pod, 30 individuals) were photographically identified in Chatham Strait, Southeast Alaska (northwest of Behm Canal), in June 2007. Southern Residents were previously thought to range as far north as the Queen Charlotte Islands, BC; however, this sighting extends their known range about 200 mi. to the north (Carretta et al., 2016c).

4.2.7.3 Population and Abundance

The 2017 best available abundance estimates for the five killer whale stocks expected to occur in the Study Area are as follows: Alaska Resident stock = 2,347 animals; Northern Resident stock = 261 animals; West Coast Transient stock = 243 animals; Offshore stock = 240 animals; and Southern Resident stock = 77 individuals (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017; Muto et al., 2018b). For the Offshore portion of the Study Area and based on summer/fall surveys from 1996 to 2014, the abundance of killer whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 224 animals (Barlow, 2016). This abundance estimate is for animals from the Offshore and West Coast Transient stocks (Carretta et al., 2017c; Carretta et al., 2018b).

4.2.8 Mesoplodont Beaked Whales (*Mesoplodon spp.*)

4.2.8.1 Status and Management

None of the Mesoplodont beaked whales are considered a threatened or endangered species under the ESA, and none of the stocks are considered depleted under the MMPA. Due to the difficulty in distinguishing the different *Mesoplodon* species from one another at sea during surveys, NMFS has defined a single management unit ("Mesoplodont beaked whales") for all *Mesoplodon* stocks that occur along the U.S. West Coast (Carretta et al., 2017c). The stock assigned to that management unit is considered the California, Oregon, Washington stock (Carretta et al., 2017c). The six species in this Mesoplodont beaked whales management unit are Blainville's beaked whale (*M. densirostris*), Hubbs' beaked whale (*M. carlhubbs*i), Perrin's beaked whale (*M. perrini*), pygmy beaked whale (*M. peruvianus*), gingko-toothed beaked whale (*M. gingkodens*), and Stejneger's beaked whale (*M. stejnegeri*). Stejneger's beaked whale is the only species of *Mesoplodon* known to occur in Alaska waters (Muto et al., 2017). In addition to the California, Oregon, and Washington stock of Mesoplodont beaked whales, the population of Stejneger's beaked whales in Alaska is recognized as the Alaska stock, separately from Stejneger's and other Mesoplodont beaked whales found off California, Oregon, and Washington (Carretta et al., 2017c; Muto et al., 2017).

4.2.8.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit both slope and deep oceanic waters with depths greater than 200 m and frequently where depths are greater than 1,000 m (Baird et al., 2010; Jefferson et al., 2015; MacLeod et al., 2006; MacLeod et al., 2003; MacLeod & D'Amico, 2006; Schorr et al., 2014). As available, relevant species-specific distribution information is summarized below for the six Mesoplodont beaked whales that are included in the NMFS management unit.

Blainville's beaked whale is one of the most widely distributed species within the *Mesoplodon* genus found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Baumann-Pickering et al., 2014; Jefferson et al., 2015; Leslie et al., 2005; MacLeod, 2000; MacLeod & Zuur, 2005; Mahaffy et al., 2015). There was one confirmed sighting of Blainville's beaked whale approximately 150 NM off the coast of Southern Oregon during a NMFS survey (Hamilton et al., 2009). An acoustic monitoring device offshore off Washington detected Blainville's beaked whale pulses once, in March 2011 (Širović et al. 2012b), but none have been detected in similar acoustic monitoring efforts since (Debich et al., 2014; Kerosky et al., 2013; Trickey et al., 2015).

Hubbs' beaked whale distribution is generally associated with the deep subarctic current system along the Pacific coast of North America (Mead et al., 1982; Mead, 1989; Yamada et al., 2012). MacLeod and D'Amico (2006) speculated that the distribution of Hubbs' beaked whale might be continuous across the North Pacific between about 30° N and 45° N, but this remains to be confirmed. There was one sighting of Hubb's beaked whale off the coast of Washington (beyond approximately 300 NM) during a NMFS survey (Hamilton et al., 2009), and there are records of the species having stranded at least seven times in British Columbia (Willis & Baird, 1998b) and once at La Push, Washington (National Marine Fisheries Service, 2017a). The characteristics of its vocalizations are not presently known so the species has not been identified in acoustic monitoring records (Baumann-Pickering et al., 2014).

Perrin's beaked whale distribution generally includes deep waters off the Pacific coast of North America where depths exceed 1,000 m (MacLeod & D'Amico, 2006). Perrin's beaked whale is known only from five stranded specimens along the California coastline south of Monterey from 1975 to 1997, and given the scarcity of data regarding the species, the full extent of Perrin's beaked whale distribution is unknown (Dalebout et al., 2002; MacLeod et al., 2006). The properties of echolocation signals produced by this species are unknown, and those thought to possibly be produced by Perrin's beaked whales have not been detected in the Study Area (Baumann-Pickering et al., 2012).

Pygmy beaked whale distribution is based on stranding data from the Pacific coast of Mexico, Peru, and Chile (MacLeod & D'Amico, 2006; Pitman & Lynn, 2001; Sanino et al., 2007); sightings during NMFS surveys indicate the species appears to be endemic to the eastern tropical Pacific between about 30° N to 30° S (Hamilton et al., 2009; MacLeod & D'Amico, 2006). The properties of echolocation signals produced by this species are unknown, and those thought to possibly be produced by Pygmy beaked whales have not been detected in the Study Area (Baumann-Pickering et al., 2012).

Ginkgo-toothed beaked whale distribution likely includes deep waters off the Pacific coast of North America. The handful of known records of the ginkgo-toothed beaked whale is from strandings, one of which occurred in California (Jefferson et al., 2015; MacLeod & D'Amico, 2006). The properties of echolocation signals produced by this species are unknown, and those thought to possibly be produced

by ginkgo-toothed beaked whales have not been detected in the Study Area (Baumann-Pickering et al., 2012).

Stejneger's beaked whale appears to prefer cold temperate and subpolar waters on the steep slope of the continental shelf in water depths ranging from 730 to 1,560 m (Loughlin & Perez, 1985; MacLeod et al., 2006; Mead, 1989). The farthest south this species has been observed in the eastern Pacific is Cardiff, California (33° N); this was previously considered an extralimital occurrence (Loughlin & Perez, 1985; MacLeod et al., 2006; Mead, 1989), but acoustic monitoring has since on rare occasions detected vocalizations in Southern California waters, confirming the species' range that far south (Baumann-Pickering et al., 2012). Stejneger's beaked whales have only been visually detected twice during NMFS surveys, once in the Aleutian Islands and once in the Gulf of Alaska (Hamilton et al., 2009). Stejneger's beaked whales were the most consistently detected beaked whale off Washington between September and June in multiple years of acoustic monitoring effort (Baumann-Pickering et al., 2012; Debich et al., 2014; Kerosky et al., 2013; Širović et al., 2012; Trickey et al., 2015).

Offshore. There were a total of 16 sightings of species identified to the genus *Mesoplodon* based on surveys from 1991 to 2014 for the combined Oregon/Washington stratum and the Northern California stratum (Barlow, 2016), which approximates the Offshore portion of the Study Area. Given these sightings and the consistent acoustic monitoring detections from species in the management unit, Mesoplodont beaked whales are expected to have a regular presence in the Offshore portion of the Study Area.

Inland Waters. Based on the available information (National Marine Fisheries Service, 2017a; U.S. Department of the Navy, 2017f), beaked whales are not expected to occur within the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. There is no indication that beaked whales inhabit the Behm Canal portion of the Study Area (Dahlheim et al., 2009; Muto et al., 2017), and they are considered extralimital in this location.

4.2.8.3 Population and Abundance

There is currently no reliable abundance estimate for the Alaska stock of Stejneger's beaked whale. With the approximate distribution believed to be well offshore of the Pacific coast of Southeast Alaska (Muto et al., 2017), the Navy presumes there will be no Stejneger's or other Mesoplodont beaked whales present in Behm Canal.

For the Offshore portion of the Study Area and based on surveys from 1991 to 2014, the abundance for Mesoplodont beaked whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 1,036 animals (Barlow, 2016).

4.2.9 Northern Right Whale Dolphin (*Lissodelphis borealis*)

4.2.9.1 Status and Management

Northern right whale dolphins are not considered a threatened or endangered species under the ESA and are not considered depleted under the MMPA. Northern right whale dolphins are present in the Offshore portion of the Study Area, and those animals have been assigned to the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.9.2 Geographic Range and Distribution

The northern right whale dolphin occurs in cool-temperate to subarctic waters of the North Pacific Ocean, from the west coast of North America to Japan and Russia (Jefferson et al., 2015). The species does not migrate, although shifts in abundance and distribution may vary seasonally or between years (Barlow, 2016; Becker et al., 2014; Dohl et al., 1983; Douglas et al., 2014; Forney & Barlow, 1998; Jefferson et al., 2015). Based on habitat models developed with line-transect survey data collected off the U.S. West Coast during summer and fall from 1991 to 2009, Becker et al. (2016) found that encounters of northern right whale dolphin increased in shelf and slope waters, and encounters decreased substantially in waters warmer than approximately 64°F (18°C).

In the NMFS 2014 survey of the U.S. West Coast, all of the sightings of northern right whale dolphins were in the Oregon/Washington stratum, which is indicative of a distributional shift to the north in comparison to the species' previous distributions during three surveys undertaken between 2001 and 2008 (Barlow, 2016). Although the NMFS surveys provide limited coverage for nearshore waters, aerial surveys conducted in the approximate nearshore half of the Study Area in 2011 and 2012 (Adams et al., 2014) were consistent with the findings from the 2014 NMFS survey.

Offshore. Aerial surveys conducted in waters off southern Washington, Oregon, and Northern California covering the approximate nearshore half of the Study Area in the spring, summer, and fall of 2011 and 2012 found that northern right whale dolphins were approximately the second-most-frequently detected marine mammal in the area (Adams et al., 2014). For purposes of the analysis in this Request for LOAs, Northern right whale dolphins are considered to have a regular presence in the Offshore portion of the Study Area.

Inland Waters. Northern right whale dolphins are considered extralimital in the Inland Waters portion of the Study Area based on past sightings and stranding records (National Marine Fisheries Service, 2017a; U.S. Department of the Navy, 2017f).

Western Behm Canal, Alaska. Northern right whale dolphins are not expected to occur within the Behm Canal portion of the Study Area based on surveys conducted in Southeast Alaska from 1991 to 2007 (Dahlheim et al., 2009).

4.2.9.3 Population and Abundance

The most recent NMFS survey in 2014 found northern right whale dolphin abundance higher than in the previous three surveys between 2001 and 2008 (Barlow, 2016). For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance for northern right whale dolphins in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 17,228 animals (Barlow, 2016).

4.2.10 Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*)

4.2.10.1 Status and Management

Pacific white-sided dolphins are not considered a threatened or endangered species under the ESA, and neither stock in the Study Area is considered depleted under the MMPA. Pacific white-sided dolphin in the Behm Canal portion of the Study Area are from the North Pacific stock (Muto et al., 2017; Muto et al., 2018b), and those in the Offshore and Inland Waters portion are from the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.10.2 Geographic Range and Distribution

Pacific white-sided dolphins are found in cold temperate waters across the northern rim of the Pacific Ocean as far north as the southern Bering Sea and as far south as the Gulf of California off Mexico (Dahlheim et al., 2009; Ferguson, 2005; Hamilton et al., 2009; Jefferson et al., 2015; Leatherwood et al., 1984; Reeves et al., 2002). The species is also known to inhabit inshore regions of southeast Alaska, British Columbia, and Washington (Brownell et al., 1999; Dahlheim et al., 2009; Forney & Barlow, 1998; U.S. Department of the Navy, 2017f; Williams & Thomas, 2007).

Like other species, Forney and Barlow (1998) found Pacific white-sided dolphins may occasionally shift their distribution in response to changes in oceanographic conditions. Based on passive acoustic monitoring recordings, Pacific white-sided dolphins are the most commonly detected odontocete off Washington, present for 9–10 months each year (Klinck et al., 2015a; Oleson & Hildebrand, 2012; Širović et al., 2012). Aerial surveys conducted in waters off Washington, Oregon, and Northern California in the spring, summer, and fall of 2011 and 2012 found Pacific white-sided dolphins present in all three survey seasons. They were the second-most-frequently sighted species, and the sightings included two encounters with large pods estimated to number 955 individuals (Adams et al., 2014). Based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, Pacific white-sided dolphins are distributed throughout the Offshore portion of the Study Area during the summer and fall (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2016; Forney et al., 2012). In the NMFS 2014 survey of the U.S. West Coast, sightings of Pacific white-sided dolphins were very low in Southern and central California, indicative of a distributional shift to the north in comparison to their previous distribution found during the three surveys undertaken between 2001 and 2008 (Barlow, 2016).

Offshore. For the Offshore portion of the Study Area, the Navy assumes Pacific white-sided dolphins may be present year round, with increased abundance in the summer and fall seasons.

Inland Waters. With the exception of reported opportunistic sightings of the species in the Strait of Juan de Fuca and the waters around the San Juan Islands, there have been very few sightings in the Inland Waters area in the last decade, and none were detected during aerial surveys of Puget Sound between 2013 and 2016 (Smultea et al., 2017; U.S. Department of the Navy, 2017f). Pacific white-sided dolphin occurrence in the Inland Waters is considered rare with the exception of southern Puget Sound, where occurrence is considered extralimital.

Western Behm Canal, Alaska. Based on survey data from Southeast Alaska (Dahlheim et al., 2009), Pacific white-sided dolphins may occur within the Behm Canal portion of the Study Area.

4.2.10.3 Population and Abundance

Although the species was sighted in relatively high numbers in Southeast Alaska (Dahlheim et al., 2009), there is no estimate of a specific abundance for Pacific white-sided dolphins in the Behm Canal or the broader Southeast Alaska region. The stock assigned to Pacific white-sided dolphin is for all animals in the North Pacific north of 45° North from Southeast Alaska to the Aleutian Islands (Muto et al., 2017; Muto et al., 2018b). Based on marine mammal sighting data collected in the central North Pacific from 1987 to 1990, the population for this stock is 26,880 individuals (Muto et al., 2017; Muto et al., 2018b).

In the 2014 NMFS survey that included the NWTT Offshore area, Pacific white-sided dolphin abundance was fairly typical of their abundance in the previous three surveys between 2001 and 2008 (Barlow,

2016). For the Offshore portion of the Study Area based on surveys from 1991 to 2014, the abundance of Pacific white-sided dolphins in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 18,680 animals (Barlow, 2016).

4.2.11 Pygmy Sperm Whale (*Kogia breviceps*)

4.2.11.1 Status and Management

Pygmy sperm whales are not considered a threatened or endangered species under the ESA and are not considered depleted under the MMPA. Pygmy sperm whales in the Offshore portion of the Study Area are from the California, Oregon, Washington stock (Carretta et al., 2017). Along the U.S. West Coast and because of the difficulty distinguishing between pygmy and dwarf sperm whales at sea, identifications during surveys have generally been to *Kogia* spp. as the lowest taxonomic level of identification possible (Barlow, 2016; Carretta et al., 2017c; Hamilton et al., 2009). As a result, metrics for the population in the SAR for U.S. West Coast are for *Kogia* spp. (Carretta et al., 2017c).

4.2.11.2 Geographic Range and Distribution

There has only been one sighting identified as *Kogia* spp. north of California on any of the survey efforts between 1991 and 2014 (Barlow, 2016; Hamilton et al., 2009). It has been suggested that most of the sightings identified as *Kogia* spp. were probably pygmy sperm whales (Carretta et al., 2017c). The presence of pygmy sperm whales in the Study Area is also suggested by the occurrence of three strandings confirmed as pygmy sperm whale (one individual in Oregon in 2006 and 2016; one in Washington in 2005) and one stranded unidentified *Kogia* spp. Washington in 2007 (National Marine Fisheries Service, 2017a).

Offshore. Pygmy sperm whales are expected to be present year round in the Offshore portion of the Study Area.

Inland Waters. Pygmy sperm whales are not expected to occur within the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. Pygmy sperm whales are not expected to occur within the Behm Canal portion of the Study Area.

4.2.11.3 Population and Abundance

For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance for *Kogia* spp. in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 766 animals (Barlow, 2016).

4.2.12 Risso's Dolphin (*Grampus griseus*)

4.2.12.1 Status and Management

Risso's dolphins are not considered a threatened or endangered species under the ESA and are not considered depleted under the MMPA. Risso's dolphins in the Offshore and Inland Waters portions of the Study Area are from the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.12.2 Geographic Range and Distribution

Risso's dolphins are not present in Alaska waters. In the Pacific off the U.S. West Coast, Risso's dolphins are found along the continental slope, over the outer continental shelf (Baumgartner, 1997; Cañadas et al., 2002; Cetacean and Turtle Assessment Program, 1982; Davis et al., 1998; Green et al., 1992; Kruse et al., 1999; Mignucci-Giannoni, 1998), and over submarine canyons (Mussi et al., 2004). Surveys off southern Washington, Oregon, and Northern California in the spring, summer, and fall of 2011 and 2012 found Risso's dolphins mostly at the outer-shelf and slope domains between the 200 m and 2,000 m depth stratum (Adams et al., 2014), which was consistent with the distribution of vocalizing Risso's dolphins detected during acoustic monitoring during the same approximate timeframe (Klinck et al., 2015a). Based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, relatively high densities of Risso's dolphin are predicted in the Offshore portion of the Study Area during the summer and fall (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2016; Forney et al., 2012).

Offshore. In surveys of waters within the Offshore portion of the Study Area between 2011 and 2014, Risso's dolphins were found to be fewer in number than Dall's porpoises, but tended to occur in large pods with a mean group size of approximately 17 (Barlow, 2016), and maximum group sizes occasionally exceeding 100 individuals (Adams et al., 2014). Risso's dolphins are expected to be present in the area year round.

Inland Waters. This species is not expected to regularly occur within the Inland Waters portion of the Study Area. There has been only one stranding of the species in the inland waters since 2000 (March 2015 at Samish Bay), which involved a single individual (National Marine Fisheries Service, 2017a). There were reported sightings of a pair of Risso's dolphins in Puget Sound from the winter of 2011 (Cascadia Research Collective, 2011) off and on through 2013 (U.S. Department of the Navy, 2017f). Aerial surveys in Puget Sound reported two sightings of a pair of Risso's dolphins in 2013, but none were seen during surveys in 2014, 2015, and 2016 (Smultea et al., 2017) and there were no reports of sightings subsequent to 2013 (U.S. Department of the Navy, 2017f). As a result of these findings, Risso's dolphins are considered rare in the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. Risso's dolphins are not expected to occur within the Behm Canal portion of the Study Area, given there is no indication that they inhabit the area (Dahlheim et al., 2009; Muto et al., 2017) and are considered extralimital in this region.

4.2.12.3 Population and Abundance

For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance of Risso's dolphins in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 4,906 animals (Barlow, 2016).

4.2.13 Short-Beaked Common Dolphin (*Delphinus delphis*)

4.2.13.1 Status and Management

Short-beaked common dolphins are not considered a threatened or endangered species under the ESA and are not considered depleted under the MMPA. Short-beaked common dolphins in the Offshore and Inland Waters portions of the Study Area are from the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.13.2 Geographic Range and Distribution

Short-beaked common dolphins are not present in Alaska waters. Short-beaked common dolphins are mostly a warm temperate to tropical species having densities that are greatest when waters are warmest (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2014; Becker et al., 2016; Forney & Barlow, 1998; Forney et al., 2012). Shifts in distribution are pronounced with seasonal and year-to-year changes in oceanographic conditions; movements may be north-south or inshore-offshore (Barlow et al., 2009; Becker et al., 2014; Becker et al., 2016; Forney & Barlow, 1998; Forney et al., 2012; Henderson et al., 2014a). Short-beaked common dolphin have been encountered in the Offshore portion of the Study Area occasionally, as far north as approximately the Washington/Canada border (Adams et al., 2014; Barlow, 2016; Forney, 2007; Hamilton et al., 2009). However, based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, very low densities of short-beaked common dolphins are predicted in the Offshore portion of the Study Area during the summer and fall (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2016; Forney et al., 2012).

Offshore. In aerial surveys conducted in waters off southern Washington, Oregon, and Northern California covering the approximate nearshore half of the Study Area in the spring, summer, and fall of 2011 and 2012, there was only one sighting of short-beaked common dolphins in nearshore waters off Northern California (Adams et al., 2014). During the NMFS 2014 survey, there were no short-beaked common dolphins sighted north of central Oregon (approximately 44° North), and all of those sightings were in the deep ocean beyond the continental shelf (Barlow, 2016). For purposes of the analysis in this Request for LOAs, short-beaked common dolphins are considered to have a regular presence in the Offshore portion of the Study Area.

Inland Waters. This species is not expected to regularly occur within the Inland Waters portion of the Study Area. A sighting of a pair of short-beaked common dolphins in Puget Sound in 2003 (U.S. Department of the Navy, 2017f) is the only record of this species in the Inland Waters portion of the Study Area. Given the normal distribution of the species and the sightings record, short-beaked common dolphins are considered rare in the Inland Waters of the Study Area.

Western Behm Canal, Alaska. Short-beaked common dolphins are not expected to occur within the Behm Canal portion of the Study Area, given there is no indication that they inhabit the area (Dahlheim et al., 2009; Muto et al., 2017) and are considered extralimital in this region.

4.2.13.3 Population and Abundance

For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance for short-beaked common dolphins in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 137,381 animals (Barlow, 2016). Over the period of the surveys, there has been a nearly monotonic increase in abundance of short-beaked common dolphins along the U.S. West Coast (Barlow, 2016).

4.2.14 Short-finned Pilot Whale (*Globicephala macrorhynchus*)

4.2.14.1 Status and Management

Short-finned pilot whales are not considered a threatened or endangered species under the ESA and are not considered depleted under the MMPA. Short-finned pilot whales in the Offshore and Inland Waters portions of the Study Area are from the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.14.2 Geographic Range and Distribution

The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world coinciding with the abundance of squid, their preferred prey (Bernard & Reilly, 1999; Hui, 1985; Payne & Heinemann, 1993). Pilot whales are typically distributed along the continental shelf break and movements over the continental shelf are common based on observations made off the northeastern United States (Payne & Heinemann, 1993). Short-finned pilot whales are not expected to be present in Alaskan waters based on their preference for warm water areas.

Offshore. During systematic ship surveys conducted between 1996 and 2014, short-finned pilot whales were detected in the Offshore portion of the Study Area once off southern Washington (Hamilton et al., 2009) and once off Northern California during the 2014 survey (Barlow, 2016). In aerial surveys conducted in waters off Washington, Oregon, and Northern California covering the approximate nearshore half of the Study Area in the spring, summer, and fall of 2011 and 2012, short-finned pilot whales were encountered once in a pod of eight individuals off Northern California (Adams et al., 2014). Between 2000 and 2016, there are records of one stranded individual in 2002 on the Oregon's Pacific coast, and one off Washington in 2007 (National Marine Fisheries Service, 2017a). For purposes of the analysis in this Request for LOAs, short-finned pilot whales are considered to have a regular presence in the Offshore portion of the Study Area.

Inland Waters. This species is not expected to regularly occur within the Inland Waters portion of the Study Area. There have been occasional sightings with unconfirmed and low confidence within Puget Sound attributed to possible short-finned pilot whales (U.S. Department of the Navy, 2017f). Given the normal distribution of the species and the record of sightings, short-finned pilot whales are considered rare in the Inland Waters of the Study Area.

Western Behm Canal, Alaska. Short-finned pilot whales are not expected to occur within the Behm Canal portion of the Study Area, given there is no indication that they inhabit the area (Dahlheim et al., 2009; Muto et al., 2017) and are considered extralimital in that region.

4.2.14.3 Population and Abundance

For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance for short-finned pilot whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 224 animals (Barlow, 2016).

4.2.15 Sperm Whale (*Physeter macrocephalus*)

4.2.15.1 Status and Management

Sperm whales are listed as endangered under the ESA, but there is no designated critical habitat for this species. Sperm whales in Alaska are from the North Pacific stock (Muto et al., 2017; Muto et al., 2018b) but are not expected to be present in the Behm Canal portion of the Study Area. Sperm Whales in the Offshore portion of the Study Area are from the California, Oregon, Washington stock (Carretta et al., 2017c). Both of these stocks of sperm whales are considered depleted under the MMPA.

4.2.15.2 Geographic Range and Distribution

Sperm whales are typically found in temperate and tropical waters of the Pacific (Rice, 1989). The secondary range includes the areas of higher latitudes in the northern Pacific, including Alaska (Jefferson et al., 2015; Whitehead & Weilgart, 2000; Whitehead et al., 2008; Whitehead et al., 2009). This species

appears to have a preference for deep waters (Baird, 2013; Becker et al., 2010; Becker et al., 2012a; Forney et al., 2012; Jefferson et al., 2015). Typically, sperm whale concentrations correlate with areas of high productivity. These areas are generally near drop offs and areas with strong currents and steep topography (Gannier & Praca, 2007; Jefferson et al., 2015); the semi-permanent Strait of Juan de Fuca eddy is one such area (see MacFadyen et al. (2008)). Sperm whales are somewhat migratory, as demonstrated by discovery tag data and subsequent satellite tag locational data; three sperm whales satellite-tagged off southeastern Alaska were documented moving far south to waters off Mexico and the Mexico/Guatemala border (Straley et al., 2014).

Offshore. No sperm whales were detected during systematic surveys of waters between the British Columbia border with Alaska and Washington (Williams & Thomas, 2007). In aerial surveys conducted in waters off Washington, Oregon, and Northern California covering the approximate nearshore half of the Study Area in the spring, summer, and fall of 2011 and 2012, sperm whales were encountered only twice, in deep water off the coast from Grays Harbor (Adams et al., 2014). During the NMFS 2014 summer shipboard survey in the Study Area, there were a total of five sperm whale sightings (Barlow, 2016). The variable presence of sperm whales in the area is reflected in the acoustic monitoring record of sperm whale click detections. In 2008, sperm whales were present in the acoustic record between April through November and in the following year from February through May (Oleson & Hildebrand, 2012). In similar acoustic monitoring efforts between 2010 and 2013, sperm whales were found to be present from November through June (Debich et al., 2014; Kerosky et al., 2013; Klinck et al., 2015a; Širović et al., 2012).

Inland Waters. This species is not expected to occur within the Inland Waters portion of the Study Area. Given the normal distribution of sperm whales in deep water ocean areas, they are considered extralimital in the Inland Waters of the Study Area.

Western Behm Canal, Alaska. Sperm whales are not expected to occur within the Behm Canal portion of the Study Area, given there is no indication that they inhabit the area (Dahlheim et al., 2009; Muto et al., 2017; Muto et al., 2018b) and are considered extralimital in this region.

4.2.15.3 Population and Abundance

For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance for sperm whales in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 1,001 animals (Barlow, 2016).

4.2.16 Striped Dolphin (*Stenella coeruleoalba*)

4.2.16.1 Status and Management

Striped dolphins are not considered a threatened or endangered species under the ESA and are not considered depleted under the MMPA. Striped dolphins in the Offshore portion of the Study Area are from the California, Oregon, Washington stock (Carretta et al., 2017c).

4.2.16.2 Geographic Range and Distribution

Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella*. Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. Along the west coast of North America, southern Washington State is the known northern limit of the

species (Barlow, 2016; Hamilton et al., 2009; Reeves et al., 2002). Striped dolphins are not present as far north as Alaska waters. Based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, extremely low densities of striped dolphins are predicted well offshore in the Study Area during the summer and fall (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2016; Forney et al., 2012).

Offshore. NMFS summer surveys between 1996 and 2014 only detected striped dolphins off the coast of southern Washington State and waters to the south, generally in the deep ocean beyond approximately 100 NM from shore (Barlow, 2016; Hamilton et al., 2009). Striped dolphins were not identified in aerial surveys conducted in waters inside the 2,000 m isobath off southern Washington, Oregon, and Northern California in the spring, summer, and fall of 2011 and 2012 (Adams et al., 2014), which is expected given their general offshore distribution.

Inland Waters. This species is not expected to occur within the Inland Waters portion of the Study Area. Given the normal distribution of the species, striped dolphins are considered extralimital in the Inland Waters portion of the Study Area.

Western Behm Canal, Alaska. Striped dolphins are not expected to occur within the Behm Canal portion of the Study Area, given there is no indication that they inhabit the area (Dahlheim et al., 2009; Muto et al., 2017) and are considered extralimital in this region.

4.2.16.3 Population and Abundance

For the Offshore portion of the Study Area and based on surveys from 1996 to 2014, the abundance of striped dolphins in the area (the combined Oregon/Washington stratum and the Northern California stratum) is estimated at 8,335 animals (Barlow, 2016).

4.3 PINNIPEDS

4.3.1 CALIFORNIA SEA LION (*ZALOPHUS CALIFORNIANUS*)

4.3.1.1 Status and Management

The California sea lion is protected under the MMPA and is not listed under the ESA. NMFS has defined one stock for the California sea lion (U.S. stock), with five genetically distinct geographic populations identified: (1) Pacific Temperate, (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California (Carretta et al., 2017c; Carretta et al., 2018b). The Pacific Temperate population is the only population expected in the Study Area and constitutes the U.S. stock. However, movement of sea lions between U.S. waters and Mexican waters off the Baja Peninsula has been documented, and in addition to rookeries in U.S. waters the Pacific Temperate population includes sea lions from rookeries on the Coronado Islands just south of the U.S.–Mexico border. However, pup production at the Coronado Islands is minimal compared with U.S. rookeries and does not represent a significant contribution to the overall size of the Pacific Temperate population (Carretta et al., 2017c; Carretta et al., 2018b).

4.3.1.2 Geographic Range and Distribution

California sea lions from the Pacific Temperate population migrate seasonally into the Study Area and have also been sighted north of the Study Area in Canadian waters (Carretta et al., 2017c; Carretta et al., 2018b). In summer, California sea lions breed on islands extending from the Gulf of California, Mexico to the Channel Islands; depending on oceanographic conditions and prey availability, they may travel over

300 km from island rookeries in search of prey (Melin et al., 2008). Their primary rookeries are located in the Channel Islands, specifically San Miguel, San Nicolas, Santa Barbara, and San Clemente islands. Their distribution shifts to the north in fall and to the southeast during winter and spring, probably in response to changes in prey availability (Edgell & Demarchi, 2012). In the non-breeding season, adult and subadult males migrate northward along the coast to central and Northern California, Oregon, Washington, and Vancouver Island, and return south the following spring (DeLong et al., 2017). Individuals are occasionally sighted hundreds of miles offshore (Jeffries et al., 2000; Lowry & Forney, 2005); however, most tend to forage at a maximum of approximately 20–80 NM from shore (DeLong et al., 2017; Lowry & Forney, 2005). Most adult females with pups and juveniles of both sexes remain in waters near their breeding rookeries off the coast of California and Mexico. They also enter bays, harbors, and river mouths and often haul out on man-made structures such as piers, jetties, offshore buoys, and oil platforms. Refer to the Navy's Marine Species Density Database Technical Report for more information on how abundance and distribution information was used to estimate species density (U.S. Department of the Navy, 2017a).

Offshore. California sea lions are the most frequently sighted otariid in Washington waters and use numerous haulout sites along the Pacific coast (DeLong et al., 2017; Jeffries et al., 2000; Lowry & Forney, 2005). In the Study Area, adult females and juvenile animals are rarely present, while males may be present for up to approximately 10 months of each year, returning to rookery islands in Southern California during the pupping and breeding season (May–July) (DeLong & Jeffries, 2017; DeLong et al., 2017; Laake et al., 2018). Sea lions are present along the coast of Oregon from October to April (Lowry et al., 2014). Main haulout sites include the Columbia River (South Jetty), Cascade Head, Cape Arago, and Orford and Rogue Reefs (DeLong & Jeffries, 2017). Sea lions also use the northern coast of California mainly during May and June, and September and October (Lowry & Forney, 2005; Oleson et al., 2009). Main haulout sites include St. George Reef, Castle Rock, and Farallon and Año Nuevo Islands.

California sea lions feed on a wide variety of prey, including many species of fish and squid that are typically found over the continental shelf; the availability of prey drives the distribution of California sea lions. The U.S. Geological Survey conducted seabird and marine mammal surveys off the coasts of Washington, Oregon, and Northern California in winter, summer, and fall from 2011 to 2012 (Adams et al., 2014). California sea lions were the most frequently sighted pinniped species (125 sightings and 213 individuals) and were present year round with slightly more sightings recorded during fall. The number of sightings and relative abundance decreased with distance from shore. California sea lions were most frequently observed over the inner-continental shelf, with 60 percent of sightings and 74 percent of individuals observed at depths less than 100 m (Adams et al., 2014).

Approximately 90 percent of California sea lions are expected to occur within 40 km of shore, and all are expected to occur within 70 km of shore (Lowry & Forney, 2005; Oleson et al., 2009; Wright et al., 2010). Males are present in the Offshore Area from November to mid-June, when they typically leave the Study Area en route to rookeries in the Channel Islands (DeLong & Jeffries, 2017; Gearin et al., 2017; Wright et al., 2010). Transit time between breeding rookeries and the Study Area is approximately 25 days (Gearin et al., 2017; Wright et al., 2010). Gearin (2017) shows sea lions remain within the 1,000 m isobath during north and south migrations. However, during anomalous conditions (e.g., during an El Nino period) California sea lions may travel farther offshore, presumably seeking prey (Elorriaga-Verplancken et al., 2016); Weise et al., (2006) reported seeing male California sea lions 450 km from shore, and Melin et al. (2008) reported lactating females traveling more than 300 km from shore on foraging trips.

Inland Waters. Location data from satellite tags on 30 male California sea lions over a two-year period indicated most were transient visitors to the Navy Facilities in Puget Sound (DeLong et al., 2017). As noted above, California sea lions migrate from Puget Sound to rookeries in Southern California in spring and return in fall (DeLong et al., 2017; Gearin et al., 2017; Jeffries, 2014; Jeffries et al., 2000). Adult female and juvenile sea lions are rare in Washington inland waters (DeLong et al., 2017). Transit through Strait of Juan de Fuca is described as rapid (Gearin et al., 2017). The southbound migration between Puget Sound and Southern California rookeries takes approximately 25 days (Gearin et al., 2017); therefore occurrence of any one individual in the Strait of Juan de Fuca is likely limited to several days in spring and several days in fall. However, not all sea lions would be expected to be in the strait at the same time.

Seasonal abundance in Puget Sound was estimated to be 788 California sea lions based on counts made at Navy facilities at Bremerton, Bangor, Everett, and Manchester (DeLong et al., 2017). The abundance of California sea lions in the Strait of Juan de Fuca was estimated by assuming all sea lions moved through the Strait of Juan de Fuca in spring (March through May) and fall (September through November) (DeLong & Jeffries, 2017; 2014). Some California sea lions are present year round in Puget Sound (DeLong & Jeffries, 2017; DeLong et al., 2017; Jeffries, 2014). Other established haulout sites are located at Shilshole Bay near Seattle, Commencement Bay and Budd Inlet in southern Puget Sound, and numerous navigation buoys south of Whidbey Island to Olympia (DeLong et al., 2017; Jeffries, 2014; Jeffries et al., 2000). A major winter haulout site is Race Rocks, which is located in Canadian waters of the Strait of Juan de Fuca adjacent to the Study Area (Edgell & Demarchi, 2012).

Western Behm Canal, Alaska. A total of 52 (25 male, 5 female, and 22 undetermined) California sea lions have been reported in Alaskan waters between 1974 and 2004, with an increasing presence in later years (Maniscalco et al., 2004). California sea lions in Alaska most often were seen alone and only occasionally in small groups of two or more, although hundreds have been found to haul out together along the Washington coast and in southern British Columbia. The relatively few California sea lions found in Alaska usually have been associated with Steller sea lions at their haulouts and rookeries. California sea lions are not expected to occur in Behm Canal near SEAFAC.

4.3.1.3 Population and Abundance

The current population estimate of California sea lions in the U.S. stock is 257,606 (Carretta et al., 2017c; Carretta et al., 2018b). The entire total population in U.S. waters cannot be counted because all age and sex classes are not ashore at the same time during field surveys. In lieu of counting all sea lions, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. The size of the U.S. population is then estimated from the number of births and the proportion of pups observed at surveyed rookeries (Carretta et al., 2017c; Carretta et al., 2018b; Laake et al., 2018).

Abundance in the NWTT Study Area was estimated from aerial surveys of California sea lions offshore and at haulout locations in central and Northern California conducted in May–June, September, and December of 1998 and July 1999 (Lowry & Forney, 2005). Only data from the Northern California strata were used to estimate abundance in the Study Area. Males are much more likely to migrate into the Oregon and Washington portion of the Study Area than females, but some females are likely to be present in Northern California waters during the non-breeding season, so extrapolating data from Lowry and Forney (2005) is reasonable and is possibly an overestimation of abundance in the Study Area. Abundance in the Study Area is expected to be higher in spring and fall when males are migrating to and

from rookeries in Southern California (Lowry & Forney, 2005). The abundances used to estimate sea lion densities in the Study Area ranged from near 0 in summer to over 10,000 in spring. Fall and winter abundances were approximately 7,300 and 8,500, respectively.

4.3.2 GUADALUPE FUR SEAL (*ARCTOCEPHALUS TOWNSENDI*)

4.3.2.1 Status and Management

The Guadalupe fur seal is listed as depleted under the MMPA and threatened under the ESA. The primary breeding rookery of Guadalupe fur seals is at Isla de Guadalupe, Mexico, and a second breeding population has been established at Islas San Benito, Baja California, Mexico (Esperon-Rodriguez & Gallo-Reynoso, 2012; Juárez-Ruiz et al., 2018; Maravilla-Chavez & Lowry, 1999), and are considered a single stock (Carretta et al., 2017c).

4.3.2.2 Geographic Range and Distribution

Until recently the distribution of Guadalupe fur seals in the Study Area has been documented primarily through stranding records and archeological evidence (Aurioles-Gamboa & Camacho-Rios, 2007; Aurioles-Gamboa et al., 2010; Etnier, 2002; Lambourn et al., 2012; National Marine Fisheries Service, 2017a; Norris, 2017a; Rick et al., 2009). Norris (2017b) describes preliminary results of an ongoing study tracking satellite-tagged fur seals as they migrate from rookeries on Isla de Guadalupe, Mexico and rehabilitated fur seals released off of Southern California. While a small percentage of adult and juvenile fur seals may migrate north of Point Cabrillo, California, and into the Study Area, the majority of Guadalupe fur seals that migrate into the Study Area are likely weaned pups and yearlings less than two years old. Refer to the Navy's Marine Species Density Database Technical Report for more information on how abundance and distribution information was used to estimate species density (U.S. Department of the Navy, 2017a).

Offshore. During the summer breeding season adult and juvenile Guadalupe fur seals are mainly distributed offshore of Baja California, Mexico, around rookeries on Isla de Guadalupe and Islas San Benito, Baja California, Mexico (Esperon-Rodriguez & Gallo-Reynoso, 2012; Juárez-Ruiz et al., 2018; Maravilla-Chavez & Lowry, 1999). During other times of the year, adult and juvenile fur seals, particularly males, are more widely distributed; however, very few are expected to migrate into the Study Area (Norris, 2017b). A large percentage of weaned pups and yearlings (fur seals less than two years old) are likely to migrate into the Offshore Area and remain there year round, with greater abundance expected from May to at least November (i.e., in summer and fall). Guadalupe fur seals are known to forage primarily off the continental shelf (beyond the 200 m isobath) and in pelagic waters where their preferred prey, squid and other cephalopods, are known to occur (Gallo-Reynoso & Esperón-Rodríguez, 2013). Foraging in coastal waters is not uncommon; however, the pursuit of prey can take them out to at least 300 km from shore, and it would not be uncommon to encounter fur seals foraging 700 km from shore (Norris, 2017b).

Inland Waters. Guadalupe fur seals are pelagic outside of the breeding season and are not expected to occur within the Inland Waters portion of the Study Area. Several rehabilitated fur seals between 10 and 15 months old were fitted with satellite tracking tags and released off Pt. Reyes, California from 2015 through 2017 (Norris, 2017b). Several of these animals remained close to shore as they migrated north and spent most of their time over the continental shelf. In contrast, "wild" Guadalupe fur seal pups and yearlings that migrated from Isla de Guadalupe, Mexico after the breeding season remained seaward of the continental shelf in deep pelagic waters. Even though the rehabilitated fur seals tended to remain

closer to shore, they are not considered representative of the population as a whole, which is expected to remain in pelagic waters beyond the continental shelf. Healthy Guadalupe fur seals are not expected to haul out in the Study Area (Norris, 2017b).

Western Behm Canal, Alaska. Guadalupe fur seals are not expected to occur within the Western Behm Canal portion of the Study Area (Norris, 2017b).

4.3.2.3 Population and Abundance

The abundance estimate for the entire stock of Guadalupe fur seals is over 33,000 animals. The abundance is based on surveys of fur seals on Isla de Guadalupe, Mexico from 2008 to 2010; population estimates of fur seals breeding at a smaller rookery on Islas San Benito, Baja California, Mexico; and an average annual growth rate of 7.64 percent applied from 2010 to 2017 (Carretta et al., 2017a; Norris, 2017b).

4.3.3 HARBOR SEAL (*PHOCA VITULINA*)

4.3.3.1 Status and Management

There are no harbor seals listed under the ESA in the Study Area and no designated critical habitat. For management purposes under the MMPA, differences in mean pupping date, movement patterns, pollutant loads, and fishery interactions have led NMFS to recognize 17 stocks within U.S. waters from California to Alaska (Carretta et al., 2017c; Muto et al., 2017; Muto et al., 2018b). As shown in Table 3-1, out of these 17 stocks there are six present in the Study Area. The Clarence Strait stock is the only stock within the Western Behm Canal portion of the Study Area. Within U.S. West Coast waters (excluding Alaska), five stocks of harbor seals are recognized: (1) Oregon/Washington Coast, (2) California, (3) Washington Northern Inland Waters (including Puget Sound north of the Tacoma Narrows Bridge, the San Juan Islands, and the Strait of Juan de Fuca); (4) Southern Puget Sound (south of the Tacoma Narrows Bridge), and (5) Hood Canal (Carretta et al., 2017c).

4.3.3.2 Geographic Range and Distribution

Harbor seals are a coastal species, rarely found more than 25–30 km from shore, and frequently occupy bays, estuaries, and inlets (Bailey et al., 2014; Baird, 2001; Oleson et al., 2009). Ideal harbor seal habitat includes access to numerous haulout sites, shelter during the breeding periods, and sufficient food (London et al., 2012; Peterson et al., 2012; Simpkins et al., 2003; Womble et al., 2015). Haulout areas can include intertidal and subtidal rock outcrops, sandbars, sandy beaches, peat banks in salt marshes, and manmade structures such as log booms, docks, and recreational floats (Jefferson et al., 2017; Jeffries, 2014; Jeffries et al., 2000; London et al., 2012; Smultea et al., 2017). Harbor seals in the Study Area may be hauled out approximately 65 percent of time, although duration can vary by season, sex, and lifestage (Huber et al., 2001). Harbor seals do not make extensive pelagic migrations, showing strong fidelity to breeding and haulout locations year round (Carretta et al., 2017c), although some long-distance movement of tagged animals in Alaska (108 mi.) and along the U.S. West Coast (up to 342 mi.) has been recorded (Brown & Mate, 1983; Womble & Gende, 2013).

Offshore. Harbor seals occur in the Offshore Area year round (Carretta et al., 2017c; Jeffries et al., 2003). They spend most of their time within 25–30 km from shore and haul out frequently along the coastline (Bailey et al., 2014; Oleson et al., 2009). Visual and acoustic surveys conducted off the Washington coast noted that a few harbor seals were sighted out to 64 km from shore, with the farthest sighting at 70 km from shore and near the 1,000 m isobath, particularly in spring, indicating that they do

range into deeper waters (Oleson et al., 2009). The U.S. Geological Survey conducted seabird and marine mammal surveys off the coasts of Washington, Oregon, and Northern California in winter, summer, and fall from 2011 to 2012 (Adams et al., 2014). Harbor seals were the second-most-frequently-sighted pinniped (out of five species), with a total of 40 sightings and 56 individuals observed. Harbor seals occurred in all three seasons but were most frequently sighted in winter when 50 percent of sightings and 63 percent of individuals occurred. Consistent with other coastal surveys, 93 percent of sightings and all but three individuals occurred in water depths less than 100 m, and the remaining harbor seal observations were in depths between 100 and 200 m (i.e., over the continental shelf) (Adams et al., 2014).

Inland Waters. The harbor seal is the most common, widely distributed pinniped found in Washington inland waters, and is frequently observed by recreational boaters, ferry passengers, and other users of the marine environment (Jeffries, 2014). Gaydos et al. (2013) have suggested that San Juan County, Washington, might have one of the most dense harbor seal populations in the world. Harbor seals are the most abundant marine mammal in Puget Sound and Hood Canal in particular, as they occur throughout the canal year round (Jefferson et al., 2017). London et al. (2012) identified five locations in Hood Canal as "major haul-out sites" and noted these were locations having documented human (non-Navy) disturbance. London et al. (2012) report that disturbance occurs on a regular basis and described that disturbance for four of the five sites as follows: Quilcene Bay—operational salmon net-pen floats and oyster rafts; Dosewallips—state park and marina with motorized boats, kayakers, and canoers; Hamma Hamma—working oyster farm; and Skokomish—a kayak rental facility and a tribal and commercial fisheries site. Harbor seals also haul out year round at Navy facilities, including at Naval Base Kitsap Bangor located along Hood Canal, Naval Station Everett, the Manchester fuel depot, and Naval Base Kitsap Bremerton in Puget Sound (Jeffries, 2014; Jeffries et al., 2000).

In southern Puget Sound, harbor seals haul out on a variety of substrate materials including intertidal beaches, reefs, sandbars, log booms and floats. There are five main harbor seal haulout areas, including the mouth of the Nisqually River, Cutts Island, Gertrude Island, Eagle Island, and Woodard Bay (Lambourn et al., 2010). Based on periodic aerial and boat surveys, each of these sites regularly supports a population of over 100 seals (Lambourn et al., 2010). Pupping seasons vary by geographic region, with pups born in coastal estuaries (Columbia River, Willapa Bay, and Gray Harbor) from mid-April through June; Olympic Peninsula coast from May through July; San Juan Islands and eastern bays of Puget Sound from June through August; southern Puget Sound from mid-July through September; and Hood Canal from August through January (Jeffries et al., 2000). Historically, harbor seals were thought to remain within approximately 30 km of established haulout sites; however, Peterson et al. (2012) reported on 8 out of 14 satellite-tagged males captured east of the San Juan Islands moving more than 100 km from their haulout. The results of the study also support the hypothesis that males are moving between the Oregon/Washington coastal stock and the Washington Northern Inland Waters stock and potentially mating in both locations.

Western Behm Canal, Alaska. Harbor seals from the Clarence Strait stock occur year round in southeast Alaska (Muto et al., 2017). As in other regions, harbor seals haul out along the coastline and on manmade structures, and they also will use glacial ice as haulouts in southeast Alaska. During the summer molting season they spend only about 19 percent their time in the water (Simpkins et al., 2003). The rest of the year they are in the water about 43 percent of the time (Huber et al., 2001). Withrow et al. (1999) counted harbor seals at numerous sites along the eastern coast of Prince Edward Island adjacent to Clearance Strait and at haulouts in eastern Behm Canal during August of 1999. The counts

were averaged over each survey data and summed to equal over 5,400 harbor seals. No sites in Western Behm Canal were surveyed; however, harbor seals are expected to be present in Western Behm Canal.

4.3.3.3 Population and Abundance

Harbor seals are the most abundant pinniped in the Pacific Northwest. They occur in coastal waters over the continental shelf, in bays and estuaries, and in the inland waters of Washington (Huber et al., 2001). Abundances for the six stocks occurring in the Study Area are presented below.

Clarence Strait Stock: The abundance of the Clarence Strait population of harbor seals was estimated to be 31,634 in 2005. Based on an estimated annual growth rate of 2.91 percent, the abundance in 2017 is projected to be 44,632 seals (Muto et al., 2018b).

California Stock: Based on the most recent harbor seal counts (20,109 animals in May–July 2012) and a correction factor of 1.54 to account for the number of animals in the water during the time of the survey, the harbor seal population in California is estimated to be 30,968 seals (coefficient of variation = 0.157) (Carretta et al., 2017c). Trend analysis in Carretta (2017a) and preliminary analysis of recent abundance data by the Washington Department of Fish and Wildlife DeLong (2017) indicate that the California stock of harbor seals is at carrying capacity, and the current abundance estimate is appropriate for 2017.

Oregon/Washington Stock: Aerial surveys were conducted offshore in Oregon and Washington during the 1999 pupping season. Radio-tagging studies in 1991 and 1992 were considered and a correction factor was applied to account for animals in the water during the time of the survey. Based on that analysis, the most recent population estimate for the Oregon/Washington stock is 24,732. NMFS SARs do not estimate abundance based on data more than eight years old; however, trend analysis in Carretta et al. (2017c) and preliminary analysis of recent abundance data by the Washington Department of Fish and Wildlife (DeLong & Jeffries, 2017) indicate that the Oregon/Washington stock of harbor seals is at carrying capacity, and the current abundance estimate is appropriate for 2017.

Washington Northern Inland Waters Stock: The Navy sponsored aerial surveys of marine mammals, particularly harbor seals and harbor porpoises, from the summer of 2013 through the winter of 2016 in Puget Sound to update seasonal, in-water abundance and density estimates in proximity to Navy facilities in the Inland Waters portion of the Study Area (Smultea et al., 2017). An in-water abundance estimate of 3,116 harbor seals in the Washington Northern Inland Waters stock was calculated based on pooling seasonal data for the Admiralty Inlet, East Whidbey, and South Whidbey strata. Note that this in-water abundance is not equivalent to the total number of harbors seals in the stock, because it does not account for hauled-out seals. Calculating the total stock abundance based in-water surveys and separate counts of hauled-out seals is not straightforward and presents several challenges. For example, aerial surveys are conducted at randomly chosen times, but counts of hauled-out seals are typically conducted at high tide (Jefferson et al., 2017). Simply summing the two totals would invariably result in an overestimate of abundance. This abundance estimate is appropriate for 2017.

Southern Puget Sound Stock: The aerial surveys conducted by Smultea et al. (2017) from 2013 through 2016 also included Puget Sound. An in-water abundance estimate of 4,042 harbor seals in the Southern Puget Sound stock was calculated based on pooling seasonal data for the Bainbridge, Seattle, Southern Puget Sound, and Vashon strata. Note that this is an in-water abundance estimate and does not represent the abundance of the entire stock.

Hood Canal Stock: Jefferson et al. (2017) analyzed aerial survey data for Hood Canal collected during the same surveys reported on by Smultea et al. (2017). To calculate seasonal in-water abundance and density estimates for harbor seals in Hood Canal, Jefferson et al. (2017) divided the canal into six sub-regions and calculated separate estimates for each sub-region in each season (winter, spring, summer, and fall). As noted above, calculating a total abundance for harbor seals in Hood Canal based solely on aerial surveys is problematic; however, Jefferson et al. (2017) estimate that there are approximately 2,000 harbor seals in the Hood Canal stock.

Refer to the Navy's Marine Species Density Database Technical Report for more information on how abundance and distribution information was used to estimate species density (U.S. Department of the Navy, 2017a).

4.3.4 Northern Elephant Seal (*Mirounga angustirostris*)

4.3.4.1 Status and Management

The northern elephant seal is protected under the MMPA and is not listed under the ESA. NMFS has defined one stock for the northern elephant seal, the California Breeding stock, which is geographically distinct from a population in Baja California.

4.3.4.2 Geographic Range and Distribution

Northern elephant seals breed on islands offshore of California and Baja California, Mexico, from December to March. It has been suggested that since the 1990s, elephant seals in Mexico are not returning as far south as they had in the past due to warming sea and air temperatures (Garcia-Aguilar et al., 2018), which would shift their general distribution into more northern waters. Following the breeding season, they migrate north with male elephant seals migrating to the Gulf of Alaska and western Aleutian Islands while feeding along the continental shelf and females moving farther offshore into pelagic waters in the Gulf of Alaska and central North Pacific (Abrahms et al., 2017; Carretta et al., 2017c; Le Boeuf et al., 2000). Between March and August, adults return to land, primarily in the Aleutian Islands, to molt. Females arrive in March and April while males arrive later in July and August (Robinson et al., 2012; Stewart & DeLong, 1995). After molting both adult males and females return to sea to feed in spring and summer before making the return migration to breeding colonies in California and Mexico. Le Boeuf (2000) reports that 20 males fitted with satellite-tags at California breeding rookeries migrated to feeding areas off the coast of eastern Alaska and noted that all feeding areas were located near the continental shelf break. One male was tracked to the "inland passage" of southern Alaska. Robinson (2012) used satellite tracking data from 297 adult female elephant seals to show that post-breeding and post-molting foraging areas were primarily offshore in the North Pacific at the convergence of the sub-arctic and sub-tropical gyres. Peterson et al. (2015) also showed that satellite-tagged female seals migrated northwest into offshore waters of the North Pacific.

Refer to the Navy's Marine Species Density Database Technical Report for more information on how abundance and distribution information was used to estimate species density (U.S. Department of the Navy, 2017a).

Offshore. Adult male elephant seals migrate north, primarily to Alaska, following the winter breeding season. Out of 27 males tracked from rookeries off Mexico, 20 migrated to the Alaska coast, 4 terminated their migration off Canada, 2 remained off of Oregon, and 1 migrated to the Washington coast (Le Boeuf et al., 2000). Migrating elephant seals did not linger during migrations and moved

steadily and directly to their destinations during north- and south-bound migrations. After reaching their destination, they foraged in the area for one to three months. Male elephant seals are most likely to transit through the Offshore Area over approximately 30 days in March/April (northbound), June/July (southbound), August/September (northbound), and November/December (southbound) during migrations associated with breeding and molting periods (DeLong & Jeffries, 2017; Le Boeuf et al., 2000; Stewart & DeLong, 1995). Female elephant seals primarily migrated and foraged farther offshore than males, which are primarily benthic feeders, but satellite-tagged females and males followed similar migration routes (Le Boeuf et al., 2000; Robinson et al., 2012; Simmons et al., 2007).

Elephant seals were sighted during aerial surveys off the Washington coast from 2004 through 2008 (Oleson et al., 2009). Sightings occurred an average of 59 km off the coast, with most seals sighted approximately 70 km from shore and near the 1,000 m isobath. The elephant seals were an average of 13 km west of the shelf break (200 m isobath), indicating that they were foraging and migrating off the continental shelf. While migrating adult elephant seals tend to stay offshore, juveniles and sub-adults have been seen closer to shore along the coasts of Oregon, Washington, and British Columbia (Condit & Le Boeuf, 1984; Stewart & Huber, 1993). The U.S. Geological Survey conducted seabird and marine mammal surveys off the coasts of Washington, Oregon, and Northern California in winter, summer, and fall from 2011 to 2012 (Adams et al., 2014). Observers sighted northern elephant seals 31 times (33 individuals), and sightings were distributed fairly evenly across strata ranging from depths of 0 to 2,000 m. Sightings were also uniformly distributed over all three seasons (Adams et al., 2014).

Inland Waters. Jeffries (2014) observed one to three juvenile elephant seals during surveys from April to November 2013 at haulout sites in the eastern end of the Strait of Juan de Fuca. The elephant seals were hauled out with harbor seals, and the sightings were distributed evenly over the survey period. A few individuals have been seen hauled out on beaches at Destruction Island, Protection Island, and Smith and Minor islands as well as Dungeness Spit (Jeffries et al., 2000). Individuals have also been seen hauled out on Race Rocks on the Canadian side of the Strait of Juan de Fuca. Solitary individuals may occasionally be seen farther inland than the Strait of Juan de Fuca, but substantial numbers of northern elephant seals are not expected to occur in Hood Canal or Puget Sound (DeLong & Jeffries, 2017). No regular haulout sites occur in Puget Sound; however, individual elephant seals occasionally haul out for two to four weeks to molt, usually during spring and summer, and typically on sandy beaches (Calambokidis & Baird, 1994). These animals are typically yearlings or sub-adults, and their haulout locations are unpredictable. The National Stranding Network database reported one male subadult elephant seal hauled out to molt at Manchester Fuel Depot in February 2004. Rat Island across the bay from the Port Townsend ferry terminal is occasionally used by juvenile elephant seals. Most reported haulout sites are in the Strait of Juan de Fuca, and the occurrence of elephant seals in the Puget Sound region would occur infrequently and most likely during the molting season.

Migration routes of satellite-tagged adult elephant seals all remained offshore (Le Boeuf et al., 2000; Robinson et al., 2012; Simmons et al., 2007).

Western Behm Canal, Alaska. A small number of male northern elephant seals may be present in Behm Canal for brief periods in fall (September to November) and spring (April to June). The deep water (approximately 600 m) in the canal is consistent with foraging habitat preferred by male elephant seals (DeLong & Jeffries, 2017). The elephant seals would not be expected to haul out while in Behm Canal. Le Boeuf et al. (2000) noted that two out of 20 (10 percent) tagged males used inland waters in southeast Alaska and Puget Sound. This ratio (10 percent of the population) was used to estimate the

abundance of male elephant seals potentially entering Behm Canal to forage, which as noted above is approximately 8,000.

4.3.4.3 Population and Abundance

Lowry et al. (2014) reported that 40,684 pups were born on U.S. rookeries in 2010. Based on the pup count, the population estimate in the California Breeding stock is approximately 179,000 elephant seals. Assuming an annual growth rate of 3.8 percent, the projected 2017 abundance is 232,399 elephant seals potentially transiting the Offshore Area (Carretta et al., 2017c; Lowry et al., 2014).

Based on data from Jeffries (2014) and (DeLong & Jeffries, 2017), an abundance of 13 juvenile elephant seals was used to estimate potential impacts in the Inland Waters portion of the Study Area.

Only approximately 10 percent of male elephant seals are expected to enter Behm Canal and only in fall and spring (DeLong & Jeffries, 2017; Le Boeuf et al., 2000). An estimate of the male population based is 78,926 (Lowry et al., 2014). Based on the assumption that 10 percent of males use inland waters, a baseline abundance of 7,893 male elephant seals was used to estimate potential impacts on elephant seals in Behm Canal.

4.3.5 Northern Fur Seal (*Callorhinus ursinus*)

4.3.5.1 Status and Management

The Eastern Pacific stock of northern fur seals is listed as depleted under the MMPA and is not listed under the ESA. The California stock of northern fur seals is not considered to be depleted under the MMPA and is not listed under the ESA. NMFS has identified two stocks of northern fur seals in U.S. waters in the North Pacific: the Eastern Pacific stock and the California stock (Muto et al., 2017; Muto et al., 2018b). The stocks are differentiated based on high natal site fidelity and substantial differences in population dynamics. The Eastern Pacific stock breeds primarily on the Pribilof Islands (located in the Bering Sea), and the California stock breeds on San Miguel Island off Southern California and the Farallon Islands off central California (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017; Muto et al., 2018b). The distribution of the stocks overlaps during the non-breeding season, and individuals from both stocks may be present in the Study Area.

4.3.5.2 Geographic Range and Distribution

The northern fur seal is endemic to the North Pacific Ocean and occurs from Southern California to the Bering Sea, the Okhotsk Sea, and Honshu Island, Japan. Northern fur seals are on shore at breeding sites and haulouts outside of the Study Area from mid-May through mid-November (summer and fall) and at sea the remaining half of the year (winter and spring) (Carretta et al., 2017c; Carretta et al., 2018b; Melin et al., 2012; Muto et al., 2017; Muto et al., 2018b). Males move ashore at breeding sites in the Pribilof Islands from May to mid-August (depending on age) and remain on shore until October (National Marine Fisheries Service, 2007). After the breeding season, adult males move into the Gulf of Alaska north of the Study Area (Olesiuk, 2012; Sterling et al., 2014). Females arrive at breeding sites in June, pup in July, and leave in October or November. Pups are born from June through August and leave breeding sites in November, after the adults. Seasonal migrations begin in November with fur seals transiting through Aleutian Islands. Unpublished satellite tag location data indicates that while a majority of northern fur seal population remains at sea foraging in the north Pacific, a small portion of the females and juvenile males move south off the coasts of Southeast Alaska, British Columbia, Washington, Oregon, and California to forage and occasionally haul out on those coastlines. The smaller

breeding population from San Miguel Island and the Farallon Islands migrates north into the Study Area after the breeding season, arriving in the region in November and December. The return migration begins in March (Carretta et al., 2017c; Carretta et al., 2018b; Muto et al., 2017; Muto et al., 2018b). Refer to the Navy's Marine Species Density Database Technical Report for more information on how abundance and distribution information was used to estimate species density (U.S. Department of the Navy, 2017a).

Offshore. Northern fur seals are mainly pelagic in the Study Area, occurring in oceanic waters far from shore. Their offshore distribution has been correlated with oceanographic features (e.g., eddies and fronts) where prey may be concentrated (Ream et al., 2005; Sterling et al., 2014). Sightings are more common off the northern Washington and Vancouver Island coasts in winter and off central and southern Oregon in spring. Based on visual detections off Washington, Oleson (2009) described northern fur seals as occurring an average of 55 km from shore, 11 km from the 200 m isobath (a proxy for the shelf break), and in waters with a mean depth of 754 m. Kenyon and Wilke (1953) summarized information from a number of disparate sources, including sealing records and U.S. Coast Guard observations, on the migration of northern fur seals in the North Pacific. Migrating fur seals were generally found from 10 to 50 miles from shore in depths of thousands of feet (Kenyon & Wilke, 1953).

Kajimura (1984) analyzed the stomach contents of fur seals captured in the eastern North Pacific from 1958 to 1974 to better understand their foraging behavior and distribution. While the fur seals were widely distributed at sea and fed opportunistically, they were most frequently sighted between 70 and 130 km from shore, over outer continental shelf and slope. Olesiuk (2012) characterized northern fur seals as ubiquitous in the North Pacific between 60° N and 40° N latitude with their distribution at sea driven by prey concentrations associated with oceanographic features such as the boundary of the sub-arctic–sub-tropical transition zone near 42° N latitude (Polovina et al., 2001).

The U.S. Geological Survey conducted seabird and marine mammal surveys off the coasts of Washington, Oregon, and Northern California in winter, summer, and fall from 2011 to 2012 (Adams et al., 2014). Northern fur seals were sighted 35 times (47 individuals), primarily in winter and fall, with very few sightings in summer. The number of sightings and relative abundance increased with depth and distance from shore. Northern fur seals were most frequently observed beyond the-continental shelf (200 m isobath) with over 83 percent of sightings and individuals observed at depths between 200 and 2,000 m (Adams et al., 2014).

Pelland et al. (2015) examined the migratory behavior of 40 satellite-tagged female northern fur seals following their departure from breeding grounds on Bogoslof and St. Paul islands in the Aleutian Islands, Alaska. This study concentrated on foraging in the waters off Washington, but the tagged fur seals foraged along the Pacific Coast from British Columbia to central California and as far out as approximately 620 km from the shelf break (defined in the study as the 200 m isobath). The tracking data spanned seven migratory seasons from 2002 to 2010 and were compared with oceanographic data gathered from autonomous gliders deployed over the same time period and in proximity to seals' satellite tracks. A seal's extended presence in a relatively limited spatial area was presumed to represent foraging behavior and frequently coincided in space and time with oceanographic features such as eddies, fronts, chlorophyll concentrations, and river plumes within 200 km of the continental shelf break. The median (50 percent of time spent) of the cross-shore distribution had a maximum of 260 km in January and minimum of 71 km in May, presumably shifting in response to dynamic mesoscale circulation and surface wind changes. One of the 40 tagged seals spent several weeks in the spring and

early summer of 2007 following the Columbia River plume as it shifted with downwelling and upwelling favorable winds, primarily seaward of the shelf break, consistent with findings from the other tagged northern fur seals in the study (Pelland et al., 2015).

Inland Waters. The northern fur seal is a highly oceanic species. Some individuals, mostly juveniles, make their way into the Strait of Juan de Fuca and Puget Sound each year (Everitt et al., 1980), albeit not in large numbers or with any regularity. Aboriginal sealers have also reported their presence within the entrance of the Strait of Juan de Fuca (Kenyon & Wilke, 1953). Inland waters of the Puget Sound are an area of rare occurrence for this species. Northern fur seals rarely haul out on land during migrations and would not be expected at haulouts along the coast or inland (Bonnell & Dailey, 1993).

Western Behm Canal, Alaska. Satellite tracking data of female northern fur seals tagged at locations in the Bering Sea documented all bypassing the inland waters are of Southeast Alaska as they crossed the North Pacific to the continental margin of northwestern North America (Melin et al., 2012; Ream et al., 2005; Sterling et al., 2014). The tracks are consistent with the historic distribution recorded by sealing operations, which occurred only along the Pacific Coast and did not include the inland waters of Southeast Alaska (Olesiuk, 2012). Adult male fur seals remain in colder waters and are distributed in an expansive region of the North Pacific, Aleutian Islands, Gulf of Alaska, and the Bering Sea in a foraging strategy different than that of females and younger males (National Marine Fisheries Service, 2007; Sterling et al., 2014). Northern fur seals from San Miguel Island, California appear to migrate only as far north as the Washington border and not to southeast Alaska. Kenyon and Wilke (1953) reported observations of a few thousand adult female northern fur seals regularly entering inlets of southeastern Alaska to forage during the winter-spring herring runs. The herring fishery is currently closed in Behm Canal, so no fishing vessels are on site to record the presence or absence of northern fur seals; however, the fur seals are likely there from February through April (i.e., spring) but not at other times of the year (DeLong & Jeffries, 2017).

4.3.5.3 Population and Abundance

The abundance of the Eastern Pacific stock is estimated to be 626,734 animals (Muto et al., 2017), and the California stock is estimated to have an abundance of 14,050 fur seals (Carretta et al., 2017c). Adult male northern fur seals comprise approximately 7 percent of the population (43,871 fur seals) and are not expected to be in the Study Area at any time (Olesiuk, 2012). The abundance estimates are based on survey data from 2014. To arrive at a projected abundance for 2017, an annual growth rate of 8.6 percent was applied over three years. The resulting projected abundance is 764,489 and includes all females and juvenile males in both stocks as a baseline for estimating occurrence in the Study Area. Abundance is highest in winter and spring (non-breeding season), but fur seals less than three years old may remain in the Study Area year round (DeLong & Jeffries, 2017; Olesiuk, 2012).

4.3.6 Steller Sea Lion (*Eumetopias jubatus*)

4.3.6.1 Status and Management

The Western U.S. stock is listed as depleted under the MMPA and endangered under the ESA (Muto et al., 2018a; Muto et al., 2018b); however, Steller sea lions from the Western U.S. stock are not expected to be present in the Study Area, with the exception being the potential negligible presence of a few juvenile males wandering outside the core range area of the stock (DeLong, 2018; Fritz et al., 2016; Jemison et al., 2013; Raum-Suryan et al., 2004). In 1993 (58 FR 45269), areas of critical habitat for the Western DPS were designated by NMFS to include a 20 NM buffer around all major haulouts and

rookeries, as well as associated terrestrial, air, and aquatic zones, and three large offshore foraging areas that are all in Alaska waters. None of these designated areas are close (>150 km) to Western Behm Canal, and so analysis of the species critical habitat will not be discussed further in this Request for LOAs.

The Eastern U.S. stock of Steller sea lions is currently listed as depleted under the MMPA. In recognition of their recovery, Steller sea lions in the Eastern U.S. stock were removed from the List of Endangered and Threatened Wildlife in October 2013 (Muto et al., 2018a; Muto et al., 2018b; National Marine Fisheries Service, 2016a).

NMFS has designated two Steller sea lion stocks in the North Pacific, corresponding to two DPSs with the same names (Muto et al., 2017; Muto et al., 2018b). The Eastern U.S. stock (or DPS) is defined as the population occurring east of 144° W longitude, while the Western U.S. stock (or DPS) consists of sea lions occurring west of 144°W longitude. Although the distribution of individuals from the two stocks overlaps outside of the breeding season (DeLong, 2018; Fritz et al., 2016; Jemison et al., 2013; Raum-Suryan et al., 2004), only sea lions from the Eastern U.S. stock, defined as those living in southeast Alaska, British Columbia, California, and Oregon, are expected in the Study Area (DeLong, 2018; Fritz et al., 2016; Jemison et al., 2013; Raum-Suryan et al., 2004).

4.3.6.2 Geographic Range and Distribution

Steller sea lions range along the North Pacific Rim from northern Japan to California, with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands. The species is not known to migrate, but individuals disperse widely outside of the breeding season (May – early July), likely in search of different types of prey (Fritz et al., 2016; Jemison et al., 2013; Muto et al., 2017; Muto et al., 2018b; National Marine Fisheries Service, 2013a; Raum-Suryan et al., 2004; Sigler et al., 2017). Males arrive at breeding sites in May with females following shortly afterwards. Pups are born from late May to early July and begin transiting with their mothers to other haulouts at two to three months of age. Adults depart rookeries in August. Females with pups remain within 500 km of their rookery during the non-breeding season, but juveniles of both sexes and adult males disperse more widely but remain primarily over the continental shelf (Wiles, 2015).

Despite the wide-ranging movements of juveniles and adult males in particular, until recently (the past 15–30 years) there has been little evidence that breeding adults emigrated from one stock to the other (except at adjacent rookeries at the DPS boundary) (Fritz et al., 2016; Hoffman et al., 2009; Jemison et al., 2013; Muto et al., 2017; Muto et al., 2018b; Raum-Suryan et al., 2004; Trujillo et al., 2004). An analysis of over 4,000 Steller sea lions branded as pups between 2000 and 2010 from both the western and eastern DPSs revealed that juvenile males regularly crossed the DPS boundary and that there is "strong evidence" that some breeding females from the western DPS have permanently emigrated to and are reproducing in the eastern DPS (Fritz et al., 2016; Jemison et al., 2013; Raum-Suryan et al., 2004). These females are likely reproducing at rookeries at White Sisters and Grave Rocks, which are both located over 250 km north of the Behm Canal area. Females from the eastern DPS had a very low probability of migrating into the western DPS, and the majority of the overlap that does occur is present in the northern portion of Southeast Alaska (Fritz et al., 2016; Jemison et al., 2013; National Marine Fisheries Service, 2013a). Poor or declining environmental conditions in the west and favorable environmental conditions in the east are thought to have facilitated the migration of male and female Steller sea lions across the DPS boundary and resulted in higher survivability and reproductive success in the east (Jemison et al., 2013).

The locations and distribution of the Eastern population's breeding sites along the U.S. Pacific coast have shifted northward, with fewer breeding sites in Southern California and more sites established in Washington and Southeast Alaska (Pitcher et al., 2007; Wiles, 2015). Refer to the Navy's Marine Species Density Database Technical Report for more information on how abundance and distribution information was used to estimate species density (U.S. Department of the Navy, 2017a).

Offshore. Steller sea lions in the Offshore portion of the Study Area are from the Eastern stock, with the possible presence of occasional juvenile males from the Western stock. NMFS has determined that Western stock Steller sea lions are "extremely unlikely" to be present south of Sumner Strait near Wrangell Alaska (National Marine Fisheries Service, 2013a). For Washington's Pacific coast, there are unpublished reports of a branded Western DPS juvenile male Steller sea lion present in June 2005 on Tatoosh Island (at the entrance to Juan de Fuca) and another branded Western DPS juvenile male at the same general location and at Carrol Island (off southern Washington) in July and August 2013 (DeLong, 2018). Given this is an opportunistic sample, the presence of two individuals from the Western DPS over the last 12 years suggests additional Western DPS animals may occasionally be present;juvenile male Steller sea lions wandering outside the core range of the population is not uncommon (Fritz et al., 2016; Jemison et al., 2013; Raum-Suryan et al., 2004). Given the NMFS characterization that the species' presence is extremely unlikely, the Navy's assumption is that the Western DPS animals should be absent or, at most, extremely few in number in the Study Area. The Navy considers the presence of Western DPS Steller sea lions to be discountable. Furthermore, it is unlikely that they may be present contemporaneously in time and space with Navy training and testing activities. Based on the current information and assumptions, the proposed action will not affect the ESA-listed Western DPS Steller sea lions.

Steller sea lions of the Eastern stock and DPS use haulout and breeding sites primarily along the Pacific coast from the Columbia River to Cape Flattery, as well as along the coast of Vancouver Island, British Columbia (Madson et al., 2017; Wiles, 2015; Wright et al., 2017a). The distance that female sea lions travel from rookeries and haulout sites during foraging trips depends on whether or not they have dependent young (e.g., nursing pups) (Merrick & Loughlin, 1997). Females in the Aleutian Islands with dependent young traveled an average distance of 17 km on foraging trips, whereas females without dependent young traveled an average of 133 km to seek out a wider variety of prey species (Merrick & Loughlin, 1997; Trites & Porter, 2002).

Outside of breeding season, Steller sea lions may be present throughout the Offshore Area. Their distribution is likely driven by the distribution of prey, which may be concentrated in areas where oceanic fronts and eddies persist (Lander et al., 2010; Sigler et al., 2017).

Based on 11 sightings along the Washington coast, Steller sea lions were observed at an average distance of 13 km from shore and 35 km from the shelf break (defined as the 200 m isobath) (Oleson et al., 2009). The mean water depth in the area of occurrence was 42 m, and surveys were conducted out to approximately 60 km from shore. Wiles (2015) estimated that Steller sea lions off the Washington coast primarily occurred within 60 km of land, favoring habitat over the continental shelf. However, a few individuals may travel several hundred kilometers offshore (Merrick & Loughlin, 1997; Wiles, 2015). The U.S. Geological Survey conducted seabird and marine mammal surveys off the coasts of Washington, Oregon, and Northern California in winter, summer, and fall from 2011 to 2012 (Adams et al., 2014). Steller sea lions were sighted infrequently, with a total of 4 sightings and 10 individuals, all

observed over the continental shelf in depths less than 200 m. Three of the four sightings (and all but one individual) occurred in fall; the other occurred in winter (Adams et al., 2014).

Inland Waters. Eastern stock Steller sea lions occur mainly along the Washington coast from the Columbia River to Cape Flattery (Jeffries et al., 2000; Madson et al., 2017; Wiles, 2015; Wright et al., 2017a). Smaller numbers use the Strait of Juan de Fuca, San Juan Islands, and Puget Sound south to the mouth of the Nisqually River in Thurston and Pierce counties (Wiles, 2015). A total of 22 haulouts used by Eastern Stock Steller sea lions (and other pinnipeds) are located in Washington inland waters, and an additional six sites are located on the Canadian side of the Strait of Juan de Fuca and southern Strait of Georgia (Jeffries, 2014; Wiles, 2015).

While Steller sea lions are occasionally observed in the Strait of Juan de Fuca, they are seasonally present in Puget Sound. An estimate of several dozen to a few hundred Steller sea lions (mostly males) are present in Puget Sound at any given time with peak abundance in fall and winter (Smultea et al., 2017). No sea lions were sighted from May through July during aerial surveys of Puget Sound from 2014 through 2016 (Smultea et al., 2017). However, aerial surveys conducted in 2013 and 2014 recorded peak abundance of over 600 Steller sea lions on Tatoosh Island at the mouth of the Strait of Juan de Fuca in late July (Jeffries, 2014). Jeffries (2014) identified five winter haulout sites in Puget Sound used by Steller sea lions, ranging from immediately south of Port Townsend (near Admiralty Inlet) and southern Puget Sound near Olympia. At these Puget Sound haulouts, the highest total count was 50 Steller sea lions recorded in the month of November (Jeffries, 2014). Although Steller sea lions may occur through Puget Sound, they have generally been observed in greater numbers in Admiralty Inlet (Smultea et al., 2017).

Steller sea lions have been seasonally documented at Naval Base Kitsap Bangor in Hood Canal since 2008 during daily haulout surveys (Jeffries, 2014; Jeffries et al., 2000; U.S. Department of the Navy, 2016). Aerial surveys conducted by the Washington Department of Fish and Wildlife in 2013 and 2014 recorded Steller sea lions hauled out on pontoons used as security barriers at Naval Base Kitsap Bremerton and Naval Station Everett (Jeffries, 2014). There is also a large sea lion haulout (used by California and Steller sea lions) near Manchester, approximately 8 mi. from Naval Base Kitsap Bremerton. There are no known occurrences of Steller sea lions at Keyport or Crescent Harbor (Jeffries, 2014). Steller sea lions are seasonally present in large numbers in southern Puget Sound near Carr Inlet and off the mouth of the Nisqually River (Wiles, 2015).

Adjacent to the Study Area, Race Rocks is a well-established winter haulout site in the Canadian side of the Strait of Juan de Fuca used by hundreds of Steller sea lions as they enter inland waters to feed on herring (Edgell & Demarchi, 2012). Peak abundance at Race Rocks based on sightings from 1997 to 2009 occurred in October. During the summer breeding season, very few, if any, Steller sea lions would be expected in the Inland Waters portion of the Study Area (Jeffries, 2014; Smultea et al., 2017).

Western Behm Canal, Alaska. Steller sea lions from the Eastern U.S. stock are prevalent in southeast Alaska, where over 65 percent of the population in U.S. waters resides (Table 4-1). The majority of rookeries and haulout sites in southeast Alaska are located north of the Behm Canal area (Jemison et al., 2013), and there are no haulout sites in Behm Canal. The closest haulouts are West Rock, located southwest of the southern end of Behm Canal, and Nose Point, located west of the northern end of Behm Canal (DeLong & Jeffries, 2017). The West Rock haulout is used by Steller sea lions year round, and the most recent counts of non-pups were 302 and 769 in late June of 2013 and 2015, respectively. The only winter count was 334 non-pups in December 1994. The haulout at Nose Point is used only in winter (DeLong & Jeffries, 2017). As noted above, Steller sea lions from the Western U.S. stock are not

expected to be present in the Behm Canal portion of the Study Area, with the possible exception of a few wandering juvenile males (DeLong, 2018; Fritz et al., 2016; Jemison et al., 2013; National Marine Fisheries Service, 2013a).

Western stock Steller sea lions are "extremely unlikely" to be present south of Sumner Strait (National Marine Fisheries Service, 2013a), which is approximately 70 NM north of waters in the vicinity of Behm Canal. For Southeast Alaska, the majority of the documented overlap of the two DPS in the east are in "northern Southeast Alaska," with only one to two additional animals documented at haulout locations along Alaska's Pacific Coast and as far south as Forrester Island (Jemison et al., 2013); this island in the Pacific is approximately 100 NM by sea from the entrance to Behm Canal.

4.3.6.3 Population and Abundance

The Eastern U.S. stock of Steller sea lions has established rookeries and breeding sites along the coasts of California, Oregon, British Columbia, and southeast Alaska. A new rookery has recently been discovered along the coast of Washington at the Carroll Island and Sea Lion Rock complex, where more than 100 pups were born in 2015 (Muto et al., 2017; Muto et al., 2018b; Wiles, 2015). The total abundance of the Eastern U.S. stock was estimated to be 41,638 sea lions (30,917 non-pups and 10,721 pups) in 2015. This total includes Steller sea lions from rookeries and haulouts in California, Oregon, Washington (non-pups only), and southeast Alaska. Approximately 30,000 Steller sea lions occur along the coast of British Columbia but are not included in the abundance of sea lions occurring in U.S. waters. The NMFS 2016 SAR also does not factor in pups born at sites along the Washington coast (Muto et al., 2017; Muto et al., 2018b). Considering that pups have been observed at multiple breeding sites since 2013, specifically at the Carroll Island and Sea Lion Rock complex and the Tatoosh Island area (Wiles, 2015), the abundance of 1,407 non-pups reported in the Pacific SAR for Washington likely underestimates the population. Wiles (2015) estimates that up to 2,500 Steller sea lions are present along the Washington coast, which increases the abundance estimate for the Eastern U.S. stock to 42,730 sea lions (Table 4-1). Applying the trend, or growth rate, associated with each population results in a projected 2017 abundance of 45,063 Steller sea lions on U.S. waters.

Table 4-1: Abundance and Trend of Eastern U.S. Stock of Steller Sea Lions in U.S. Waters in 2015

Region	*Trend (%)*	*2015 Abundance (non-pups + pups)*	*2017 Projected Abundance*
California	1.95	4,056	4,216
Oregon	2.39	7,480	7,947
Washington	8.77	2,500	2,958
Southeast Alaska	2.33	28,594	29,942
Total Eastern U.S. Stock		**42,730**	**45,063**

Sources: (Muto et al., 2017; Muto et al., 2018b; Wiles, 2015)

5 Type of Incidental Taking Authorization Requested

The Navy requests regulations and two LOAs for the take of marine mammals incidental to proposed activities in the NWTT Study Area for the period from November 2020 through November 2027: (1) a 7-year LOA for training activities, and (2) a 7-year LOA for testing activities. The term "take," as defined in Section 3 (16 U.S.C. § 1362 (13)) of the Marine Mammal Protection Act (MMPA), means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

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

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

Although the statutory definition of Level B harassment for military readiness activities requires that the natural behavior patterns of a marine mammal be significantly altered or abandoned, the current state of science for determining those thresholds is somewhat unsettled. Therefore, in its analysis of impacts associated with acoustic sources, the Navy is adopting a conservative approach that overestimates the number of takes by Level B harassment. Many of the responses estimated using the Navy's quantitative analysis are most likely to be moderate severity (e.g., alter migration path, alter locomotion, 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, avoid area near sound source). Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As discussed in Section 6.4.2.1.1 (Criteria and Thresholds Used to Estimate Impacts from Sonar and Other Transducers – Behavioral Responses from Sonar and Other Transducers), the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements

of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences.

Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sound that may exceed an animal's behavioral threshold for only a single exposure to several minutes. It is likely that many of the estimated behavioral reactions within the Navy's quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant versus non-significant behavioral reactions are currently impossible to predict. Consequently, there is a high likelihood that large numbers of marine mammals exposed to acoustic sources are not significantly altering or abandoning their natural behavior patterns. As such, the overall impact of acoustic sources from training and testing activities on marine mammal species and stocks is negligible (i.e., cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks through effects on annual rates of recruitment or survival).

The NWTT Draft Supplemental EIS/OEIS considered all training and testing activities proposed to occur in the Study Area that have the potential to result in the MMPA-defined take of marine mammals. The Navy determined that the following three stressors could result in the incidental taking of marine mammals:

- Acoustic (sonar and other transducers),
- Explosions in water, and
- Physical disturbance and strikes (vessels).

Acoustic and explosive sources have the potential to result in incidental takes of marine mammals by harassment, injury, or mortality. Vessel strikes have the potential to result in incidental take from direct injury or mortality.

The quantitative analysis process used to estimate potential exposures to marine mammals resulting from acoustic and explosive stressors for the NWTT Draft Supplemental EIS/OEIS and this request for LOAs is detailed in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b). The Navy Acoustic Effects Model estimates acoustic and explosive effects without taking mitigation into account; therefore, the model overestimates predicted impacts on marine mammals within mitigation zones.

To account for procedural mitigation for marine species, the Navy conservatively quantifies the potential for mitigation to reduce model-estimated permanent threshold shift (PTS) to temporary threshold shift (TTS) for exposures to sonar and other transducers, and reduce model-estimated mortality to injury for exposures to explosives. For additional information on the quantitative analysis process and mitigation measures, refer to Chapter 6 (Take Estimates for Marine Mammals) and Chapter 11 (Mitigation Measures).

5.1 Incidental Take Request from Acoustic and Explosive Sources

A detailed analysis of effects due to marine mammal exposures to acoustic and explosive sources in the NWTT Study Area from Navy training and testing activities is presented in Chapter 6 (Take Estimates for Marine Mammals). Based on the quantitative analysis of acoustic and explosive sources described in Chapter 6 (Take Estimates for Marine Mammals), Table 5-1 summarizes the Navy's take request from

training and testing activities annually (based on the maximum number of activities per 12-month period) and the summation over a 7-year period.

The 7-year total impacts may be less than the sum total of each year, given that not all activities occur every year; some activities occur multiple times within a year; and some activities only occur a few times over the course of a 7-year period.

In summary, over the 7-year period being requested for both LOAs combined, the Navy's quantitative analysis for acoustic and explosive sources in NWTT estimates no mortalities, 2,879 Level A exposures, and 1,789,617 Level B exposures.

Table 5-1: Summary of Annual and 7-Year Take Request from Acoustic and Explosive Sources for NWTT Training and Testing Activities

MMPA Category	*Source*	*Annual Authorization Sought*		*7-Year Authorizations Sought*	
		Training Activities[1]	*Testing Activities*[2]	*Training Activities*	*Testing Activities*
Mortality	Explosive	None	None	None	None
Level A	Acoustic & Explosive	59 Species-specific shown in Table 5-2	439 Species-specific shown in Table 5-3	386 Species-specific shown in Table 5-22	2,493 Species-specific shown in Table 5-3
Level B	Acoustic & Explosive	59,900 Species-specific shown in Table 5-2	255,017 Species-specific shown in Table 5-3	410,192 Species-specific shown in Table 5-2	1,379,425 Species-specific shown in Table 5-3

[1] Take estimates for acoustic and explosive sources for training activities are based on the maximum number of activities in a 12-month period.

[2] Take estimates for acoustic and explosive sources for testing activities are based on the maximum number of activities in a 12-month period.

5.1.1 Incidental Take Request from Acoustic and Explosive Sources for Training Activities

Chapter 6 (Take Estimates for Marine Mammals) contains detailed species-specific results of the quantitative analysis of potential exposures to acoustic and explosive sources from training and testing activities within the NWTT Study Area. Table 5-2 summarizes the Navy's take request (exposures which may lead to Level B and Level A harassment) for training activities by species and stock breakout annually (based on the maximum number of activities per 12-month period) and the summation over a 7-year period from the quantitative analysis.

The quantitative analysis estimates no mortalities to any species from acoustic and explosive sources in NWTT. The 7-year total impacts may be less than the sum total of each year, given that not all activities

occur every year; some activities occur multiple times within a year; and some activities only occur a few times over the course of a 7-year period.

Table 5-2: Species-Specific Take Requests from Modeling Estimates of Acoustic and Explosive Sound Source Effects for All Training Activities

Species	*Stock*	*Annual*		*7-Year Total*	
		Level B	*Level A*	*Level B*	*Level A*
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Family Balaenopteridae (rorquals)					
Blue whale*	Eastern North Pacific	2	0	11	0
Fin whale*	Northeast Pacific	0	0	0	0
	California, Oregon, & Washington	54	0	377	0
Sei whale*	Eastern North Pacific	30	0	206	0
Minke whale	Alaska	0	0	0	0
	California, Oregon, & Washington	110	0	767	0
Humpback whale*	Central North Pacific	5	0	31	0
	California, Oregon, & Washington	4	0		0
Family Eschrichtiidae (gray whale)					
Gray whale	Eastern North Pacific	2	0	10	0
	Western North Pacific†	0	0	0	0
Suborder Odontoceti (toothed whales)					
Family Delphinidae (dolphins)					
Bottlenose dolphin	California, Oregon, & Washington, Offshore	5	0	33	0
Killer whale	Alaska Resident	0	0	0	0
	Eastern North Pacific Offshore	68	0	478	0
	Northern Resident	0	0	0	0
	West Coast Transient	78	0	538	0
	Southern Resident†	2	0	15	0
Northern right whale dolphin	California, Oregon, & Washington	7,941	0	55,493	0
	North Pacific	0	0	0	0

Species	***Stock***	***Annual***		***7-Year Total***	
		Level B	***Level A***	***Level B***	***Level A***
Pacific white-sided dolphin	California, Oregon, & Washington	5,284	0	36,788	0
Risso's dolphin	California, Oregon, & Washington	2,286	0	15,972	0
Short-beaked common dolphin	California, Oregon, & Washington	1,165	0	8,124	0
Short-finned pilot whale	California, Oregon, & Washington	57	0	398	0
Striped dolphin	California, Oregon, & Washington	439	0	3,059	0
Family Kogiidae (Kogia spp.)					
Pygmy sperm whale *	California, Oregon, & Washington	343	0	2,398	0
Dwarf sperm whale	California, Oregon, & Washington	38	0	266	0
Family Phocoenidae (porpoises)					
Dall's porpoise	Alaska	0	0	0	0
	California, Oregon, & Washington	13,299	8	92,793	48
Harbor porpoise	Southeast Alaska	0	0	0	0
	Northern Oregon/ Washington Coast	299	0	2,092	0
	Northern California/ Southern Oregon	21	0	145	0
	Washington Inland Waters	12,315	43	79,934	291
Family Physeteridae (sperm whale)					
Sperm whale*	California, Oregon, & Washington	512	0	3,574	0
Family Ziphiidae (beaked whales)					
Baird's beaked whale	California, Oregon, & Washington	556	0	3,875	0
Cuvier's beaked whale	California, Oregon, & Washington	1,462	0	10,209	0
Mesoplodon spp	California, Oregon, & Washington	652	0	4,549	0
Suborder Pinnipedia					
Family Otariidae (sea lions and fur seals)					
California sea lion	U.S. Stock	3,624	0	25,243	0
Steller sea lion	Eastern U.S.	108	0	743	0
Guadalupe fur seal*	Mexico	608	0	4,247	0
Northern fur seal	Eastern Pacific	2,134	0	14,911	0
	California	43	0	300	0
Family Phocidae (true seals)					

Species	*Stock*	*Annual*		*7-Year Total*	
		Level B	*Level A*	*Level B*	*Level A*
Harbor seal	Southeast Alaska - Clarence Strait	0	0	0	0
	Oregon/ Washington Coastal	0	0	0	0
	Washington Northern Inland Waters	669	5	3,938	35
	Hood Canal	2,686	1	18,662	5
	Southern Puget Sound	1,090	1	6,657	6
Northern elephant seal	California	1,909	1	13,324	1

* ESA-listed species (all stocks) within the NWTT Study Area. †Only designated stocks are ESA-listed.

5.1.2 Incidental Take Request from Acoustic and Explosive Sources for Testing Activities

Table 5-3 below summarizes the Navy's take request (exposures which may lead to Level B and Level A harassment) for testing activities by species and stock breakout annually (based on the maximum number of activities per 12-month period) and the summation over a 7-year period from the quantitative analysis. The 7-year total impacts may be less than the sum total of each year, given that not all activities occur every year; some activities occur multiple times within a year; and some activities only occur a few times over the course of a 7-year period.

The quantitative analysis estimates no mortalities to any species from acoustic and explosive sources in NWTT. The 7-year total impacts may be less than the sum total of each year, given that not all activities occur every year; some activities occur multiple times within a year; and some activities only occur a few times over the course of a 7-year period.

Table 5-3: Species-Specific Take Requests from Modeling Estimates of Acoustic and Explosive Sound Source Effects for All Testing Activities

Species	*Stock*	*Annual*		*7-Year Total*	
		Level B	*Level A*	*Level B*	*Level A*
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Family Balaenopteridae (rorquals)					
Blue whale*	Eastern North Pacific	8	0	39	0
Fin whale*	Northeast Pacific	2	0	10	0
	California, Oregon, & Washington	81	0	391	0
Sei whale*	Eastern North Pacific	55	0	263	0

Species	***Stock***	***Annual***		***7-Year Total***	
		Level B	***Level A***	***Level B***	***Level A***
Minke whale	Alaska	2	0	9	0
	California, Oregon, & Washington	195	0	930	0
Humpback whale*	Central North Pacific	117	0	594	0
	California, Oregon, & Washington	95	0	479	0
Family Eschrichtiidae (gray whale)					
Gray whale	Eastern North Pacific	153	0	469	0
	Western North Pacific†	2	0	4	0
Suborder Odontoceti (toothed whales)					
Family Delphinidae (dolphins)					
Bottlenose dolphin	California, Oregon, & Washington, Offshore	3	0	14	0
Killer whale	Alaska Resident	34	0	202	0
	Eastern North Pacific Offshore	90	0	415	0
	Northern Resident	0	0	0	0
	West Coast Transient	156	0	846	0
	Southern Resident†	0	0	0	0
Northern right whale dolphin	California, Oregon, & Washington	12,867	1	65,006	7
Pacific white-sided dolphin	North Pacific	101	0	603	0
	California, Oregon, & Washington	15,089	1	76,334	8
Risso's dolphin	California, Oregon, & Washington	4,168	0	20,100	0
Short-beaked common dolphin	California, Oregon, & Washington	984	0	3,442	0
Short-finned pilot whale	California, Oregon, & Washington	32	0	130	0

Species	***Stock***	***Annual***		***7-Year Total***	
		Level B	***Level A***	***Level B***	***Level A***
Striped dolphin	California, Oregon, & Washington	343	0	1,293	0
Family Kogiidae (Kogia spp.)					
Pygmy sperm whale*	California, Oregon, & Washington	455	1	2,162	10
Dwarf sperm whale	California, Oregon, & Washington	50	0	237	0
Family Phocoenidae (porpoises)					
Dall's porpoise	Alaska	638	0	3,711	0
	California, Oregon, & Washington	20,594	91	99,437	523
Harbor porpoise	Southeast Alaska	130	0	794	0
	Northern Oregon/ Washington Coast	64,510	113	308,067	527
	Northern California/ Southern Oregon	2,018	86	12,131	432
	Washington Inland Waters	17,637	137	117,814	930
Family Physeteridae (sperm whale)					
Sperm whale*	California, Oregon, & Washington	322	0	1,435	0
Family Ziphiidae (beaked whales)					
Baird's beaked whale	California, Oregon, & Washington	420	0	1,738	0
Cuvier's beaked whale	California, Oregon, & Washington	1,075	0	4,991	0
Mesoplodon spp	California, Oregon, & Washington	469	0	2,178	0
Suborder Pinnipedia					
Family Otariidae (sea lions and fur seals)					
California sea lion	U.S. Stock	23,994	1	103,294	5
Steller sea lion	Eastern U.S.	3,034	0	12,995	0
Guadalupe fur seal*	Mexico	902	0	4,091	0
Northern fur seal	Eastern Pacific	8,549	0	44,278	0
	California	170	0	888	0

Species	*Stock*	*Annual*		*7-Year Total*	
		Level B	*Level A*	*Level B*	*Level A*
Family Phocidae (true seals)					
Harbor seal	Southeast Alaska - Clarence Strait	2,352	0	13,384	0
	Oregon/ Washington Coastal	3,171	2	11,150	9
	Washington Northern Inland Waters	578	0	3,227	0
	Hood Canal	60,594	0	405,937	0
	Southern Puget Sound	5,748	3	39,511	24
Northern elephant seal	California	3,030	3	14,402	18

* ESA-listed species (all stocks) within the NWTT Study Area. †Only designated stocks are ESA-listed.

5.2 VESSEL STRIKES

The projected Navy vessel use has not significantly changed over time and is not projected to significantly change under the Proposed Action[5]. Integration of the Navy's Marine Species Awareness Training began in 2007 and was fully integrated across the Navy by 2009, resulting in a decrease in strike incidents Navy-wide. These factors and adaptation of additional mitigation measures since 2009 makes the period since 2009 the most appropriate for calculation of future expected strikes; while the Navy does not anticipate vessel strikes to marine mammals within the NWTT Study Area during the proposed activities, Navy vessel strikes in the Study Area for the period between 2009 and 2018 can be used to determine a statistical probability of future Navy vessel strike as a rate parameter of a Poisson distribution. To estimate the probability of 0, 1, 2, 3,… n vessel strikes involving Navy vessels over the time period considered in this request for LOAs, a simple computation can be generated: $P(X) = P(X-1)\mu/X$, where P(X) is the probability of occurrence in a unit of time (or space) and μ is the number of occurrences in a unit of time (or space). For the 10-year period from 2009 through 2018 there were 849 Navy vessel steaming days, if μ is based on two strikes over 10 years (2/849=0.002355) then μ = 0.002355. Plugging 0.002355 into the $P(0) = e^{-\mu}$ yields a values of P(0)=0.002355 strikes per day; and estimated probability of 1.36 Navy vessel strikes over a 7-year period in NWTT. As shown in Table 5-4 and during the period of time considered in this request for LOAs, there is approximately a 26 percent probability that no Navy vessel strikes will occur, a 35 percent chance one strike would occur, a 24 percent chance of two strikes, and an 11 percent chance of three strikes occurring over a 7-year period in the NWTT Study Area.

5 Projected Navy vessel use in the NWTT Study Area will slightly decrease in comparison to the past, from an average of approximately 85 steaming days per year as occurred over the 2009-2018 timeframe, to an average of approximately 83 steaming days per year projected for the time period between 2020-2026 covered in this request.

Table 5-4: Poisson Probability of Striking "X" Number of Whales When Expecting 1.36 Total Strikes over a 7-year Period in the NWTT Study Area

Predicted Number of Strikes Per Year	NWTT Study Area
No strikes	26%
1 strike	35%
2 strikes	24%
3 strikes	11%

Based on the analysis presented above, the Navy is seeking authorization for a take to account for the possibility of an accidental strike, the potential risk associated with any military vessel movement within the Study Area, and with the assumption that the populations for large whales in the NWTT Study Area are most likely to continue to increase as has generally been the trend in the recent past. The Navy will request authorization for mortality or serious injury from vessel strike over the 7-year period provided in this analysis for three (3) ship strike takes to the following species: blue whale, fin whale, Eastern North Pacific gray whale, Hawaii DPS humpback whale, minke whale, sei whale, or sperm whale.

6 Take Estimates for Marine Mammals

6.1 Estimated Take of Marine Mammals by Acoustic and Explosive Sources

Given the scope of the Navy activities at sea and the current state of the science regarding marine mammals, there is no known method to determine or predict the age, sex, or reproductive condition of the various species of marine mammals predicted to be taken as a result of the proposed Navy training and testing. Twenty-six cetacean marine mammal species are known to exist in the Study Area (see Sections 3 and 4). The method for estimating the number and types of take is described in the sections below, beginning with presentation of the criteria used for each type of take followed by the method for quantifying exposures of marine mammals to sources of energy exceeding those threshold values.

Long recognized by the scientific community (Payne & Webb, 1971), and summarized by the National Academies of Science, is the fact that human-generated sound could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council, 2005). Assessing whether sounds may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sounds, and the effects that sounds may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council, 2003, 2005), there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al., 2007; Southall et al., 2007).

Furthermore, many other factors besides just the received level of sound may affect an animal's reaction, such as the animal's physical condition, prior experience with the sound, and proximity to the source of the sound. Although it is clear that sound can disturb marine mammals and alter their behaviors temporarily, there is currently an absence of observations or measurements that demonstrate that disturbance due to intermittent sound in the water will have long-term consequences for the animal or alter their behaviors to the point that they are abandoned or significantly altered over longer periods (i.e., greater than a few hours to a few days, dependent upon the species and stressor).

6.2 Conceptual Framework for Assessing Effects from Sound-Producing Activities

A detailed discussion of the conceptual framework describing the potential effects from exposure to acoustic and explosive activities and the accompanying short-term costs to the animal (e.g., expended energy or missed feeding opportunity) can be found in Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) of the NWTT Draft Supplemental EIS/OEIS. It then outlines the conditions that may lead to long-term consequences for the individual if the animal cannot fully recover from the short-term costs and how these in turn may affect the population. This section provides a generalized description of potential outcomes for any marine animal exposed to acoustic and explosive stressors. Sections 6.4.1 (Background) and 6.5.1 (Background) provide background data specific to marine mammals based on best available science and follow this conceptual framework for acoustic and explosive stressors, respectively.

An animal is considered "exposed" to a sound if the received sound level at the animal's location is above the background ambient noise level within a similar frequency band. A variety of effects may result from exposure to acoustic and explosive activities.

The categories of potential effects are detailed in the box below.

- ***Injury*** *- Injury to organs or tissues of an animal.*
- ***Hearing loss*** *- A noise-induced decrease in hearing sensitivity which can be either temporary or permanent and may be limited to a narrow frequency range of hearing.*
- ***Masking*** *- When the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise).*
- ***Physiological stress*** *- An adaptive process that helps an animal cope with changing conditions; however, too much stress can result in physiological problems.*
- ***Behavioral response*** *- A reaction ranging from very minor and brief changes in attentional focus, changes in biologically important behaviors, and avoidance of a sound source or area, to aggression or prolonged flight.*

Figure 6-1 is a flowchart that diagrams the process used to evaluate the potential effects to marine animals exposed to sound-producing activities. The shape and color of each box on the flowchart represent either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles). Each box is labeled for reference throughout the following sections. For simplicity, sound is used here to include not only sound waves but also blast waves generated from explosive sources. Box A1, the Sound-Producing Activity, is the source of this stimuli and therefore the starting point in the analysis.

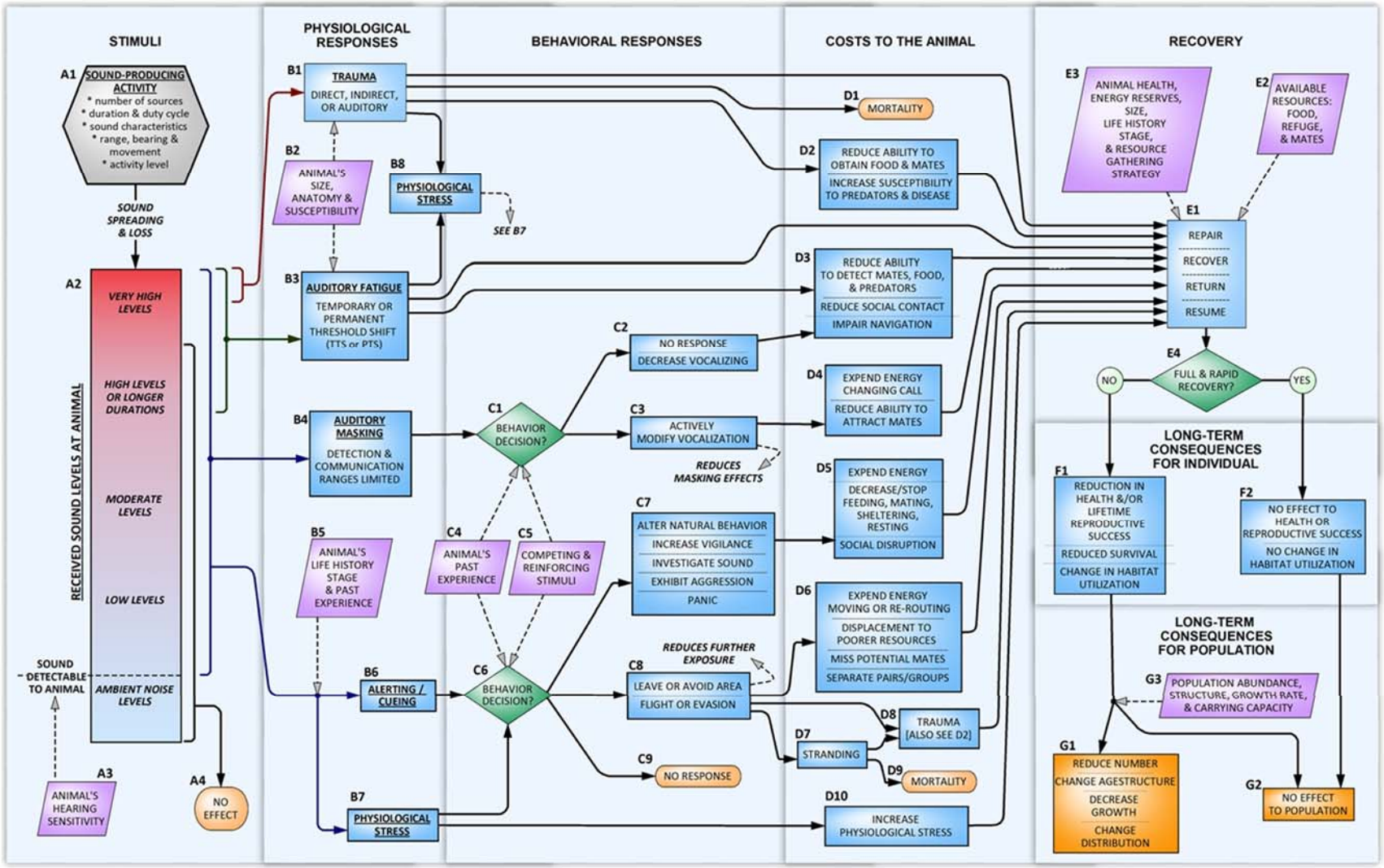


Figure 6-1. Flow Chart of the Evaluation Process of Sound-Producing Activities

6.3 HEARING AND VOCALIZATION

The typical terrestrial mammalian ear (which is ancestral to that of marine mammals) consists of an outer ear that collects and transfers sound to the tympanic membrane and then to the middle ear (Fay & Popper, 1994; Rosowski, 1994). The middle ear contains ossicles that amplify and transfer acoustic energy to the sensory cells (called hair cells) in the cochlea, which transforms acoustic energy into electrical neural impulses that are transferred by the auditory nerve to high levels in the brain (Møller, 2013). All marine mammals display some degree of modification to the terrestrial ear; however, there are differences in the hearing mechanisms of marine mammals with an amphibious ear versus those with a fully aquatic ear (Wartzok & Ketten, 1999). Marine mammals with an amphibious ear include the marine carnivores: pinnipeds, sea otters, and polar bears (Ghoul & Reichmuth, 2014; Owen & Bowles, 2011; Reichmuth et al., 2013). Outer ear adaptations in this group include external pinnae (ears) that are reduced or absent; in the pinnipeds, cavernous tissue, muscle, and cartilaginous valves seal off water from entering the auditory canal when submerged (Wartzok & Ketten, 1999). Marine mammals with the fully aquatic ear (cetaceans and sirenians) use bone and fat channels in the head to conduct sound to the ear; while the auditory canal still exists, it is narrow and sealed with wax and debris, and external pinnae are absent (Houser & Mulsow, 2016; Ketten, 1998).

The most accurate means of determining the hearing capabilities of marine mammal species are direct measures that assess the sensitivity of the auditory system (Nachtigall et al., 2000; Supin et al., 2001). Studies using these methods produce audiograms—plots describing hearing threshold (the quietest sound a listener can hear) as a function of frequency. Marine mammal audiograms, like those of terrestrial mammals, typically have a "U-shape," with a frequency region of best hearing sensitivity and a progressive decrease in sensitivity outside of the range of best hearing (Fay, 1988; Mooney et al., 2012; Nedwell et al., 2004; Reichmuth et al., 2013). The "gold standard" for producing audiograms is the use of behavioral (psychophysical) methods, where marine mammals are trained to respond to acoustic stimuli (Nachtigall et al., 2000). For species that are untrained for behavioral psychophysical procedures, those that are difficult to house under human care, or in stranding rehabilitation and temporary capture contexts, auditory evoked potential methods are increasingly used to measure hearing sensitivity (e.g., Castellote et al., 2014; Finneran et al., 2009; Montie et al., 2011; Mulsow et al., 2011; Nachtigall et al., 2007; Nachtigall et al., 2008; Supin et al., 2001).

These auditory evoked potential methods, which measure electrical potentials generated by the auditory system in response to sound and do not require the extensive training of psychophysical methods, can provide an efficient estimate of behaviorally measured sensitivity (Finneran & Houser, 2006; Schlundt et al., 2007; Yuen et al., 2005). The thresholds provided by auditory-evoked potential methods are, however, typically elevated above behaviorally measured thresholds, and auditory-evoked potential methods are not appropriate for estimating hearing sensitivity at frequencies much lower than the region of best hearing sensitivity (Finneran, 2015; Finneran et al., 2016). For marine mammal species for which access is limited and therefore psychophysical or Auditory Evoked Potential (AEP) testing is impractical (e.g., mysticete whales and rare species), some aspects of hearing can be estimated from anatomical structures, frequency content of vocalizations, and extrapolations from related species.

Direct measurements of hearing sensitivity exist for approximately 25 of the nearly 130 species of marine mammals. Table 6-1 summarizes hearing capabilities for marine mammal species in the study area. For this analysis, marine mammals are arranged into the following functional hearing groups based

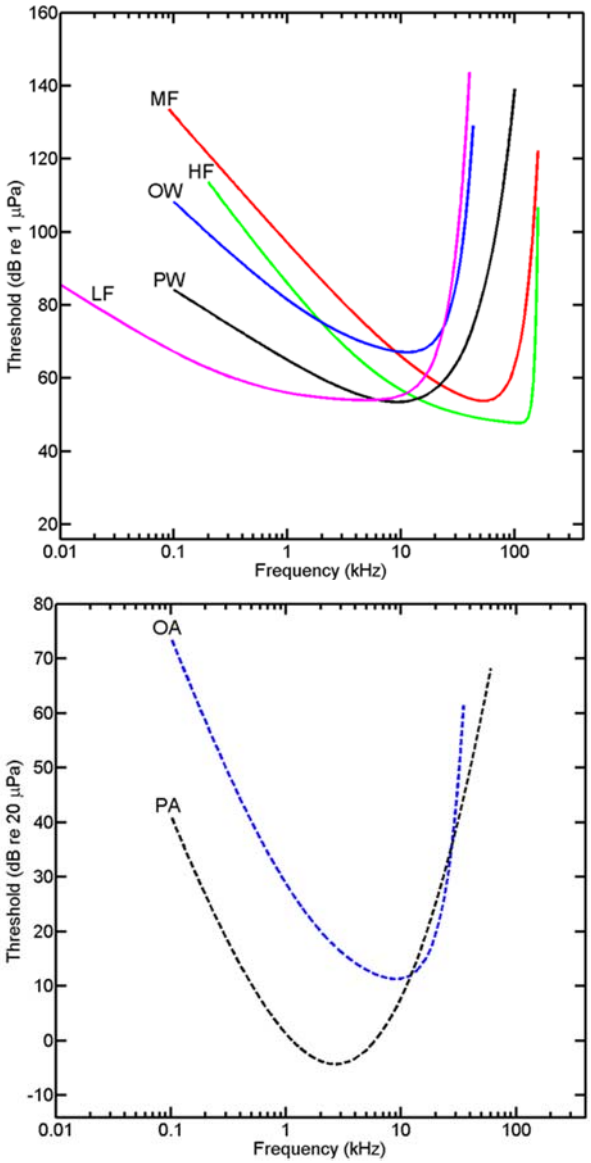
on their generalized hearing sensitivities: high-frequency cetaceans (HF group: porpoises, Kogia spp.), mid-frequency cetaceans (MF group: delphinids, beaked whales, sperm whales), low-frequency cetaceans (LF group: mysticetes), otariids and other non-phocid marine carnivores in water and air (OW and OA groups: sea lions, walruses, otters, polar bears), and phocids in water and air (PW and PA groups: true seals). Note that the designations of high-, mid-, and low-frequency cetaceans are based on relative differences of sensitivity between groups, as opposed to conventions used to describe active sonar systems.

Table 6-1: Species Within Marine Mammal Hearing Groups Likely Found in the Study Area

Hearing Group	***Species within the Study Area***
High-frequency cetaceans	Dall's porpoise
	Dwarf sperm whale
	Harbor porpoise
	Pygmy sperm whale
Mid-frequency cetaceans	Baird's beaked whale
	Common bottlenose dolphin
	Cuvier's beaked whale
	Killer whale
	Mesoplodont beaked whales
	Northern right whale dolphin
	Pacific white-sided dolphin
	Risso's dolphin
	Short-beaked common dolphin
	Short-finned pilot whale
	Sperm whale
	Striped dolphin
Low-frequency cetaceans	Blue whale
	Fin whale
	Gray whale
	Humpback whale
	Minke whale
	North Pacific Right Whale
	Sei whale
Otariids and other non-phocid marine carnivores	California sea lion
	Guadalupe fur seal
	Northern fur seal
	Northern sea otter
	Steller Sea Lion
Phocids	Harbor seal
	Northern elephant seal

For Phase III analyses, a single representative composite audiogram (Figure 6-2) was created for each functional hearing group using audiograms from published literature. For discussion of all marine mammal functional hearing groups and their derivation see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b). The mid-frequency cetacean composite audiogram is consistent with published behavioral audiograms of

killer whales (Branstetter et al., 2017a). The otariid and phocid composite audiograms are consistent with published behavioral audiograms of pinnipeds; these behavioral audiograms also show that pinniped hearing sensitivity at frequencies and thresholds far above the range of best hearing may drop off at a slower rate than previously predicted (Cunningham & Reichmuth, 2015). Lastly, Kastelein et al. (2017) published additional audiograms of harbor porpoises that were similar to previously published audiograms used to develop the high frequency cetacean composite audiogram.



Notes: (1) For hearing in water (top) and in air (bottom, phocids and otariids only). (2) LF = low frequency, MF = mid-frequency, HF =high frequency, OW = otariids and other non-phocid marine carnivores in water, PW = phocids in water, OA = otariids and other non-phocid marine carnivores in air, and PA = phocids in air.

Source: *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017).

Figure 6-2: Composite Audiograms for Hearing Groups Likely Found in the Study Area

Similar to the diversity of hearing capabilities among species, the wide variety of acoustic signals used in marine mammal communication (including biosonar or echolocation) is reflective of the diverse ecological characteristics of cetacean, sirenian, and carnivore species (see Avens, 2003; Richardson et al., 1995). This makes a succinct summary difficult (see Richardson et al., 1995; Wartzok & Ketten, 1999 for thorough reviews); however, a division can be drawn between lower-frequency communication signals that are used by marine mammals in general, and the specific, high-frequency biosonar signals that are used by odontocetes to sense their environment.

Non-biosonar communication signals span a wide frequency range, primarily having energy up into the tens of kilohertz range. Of particular note are the very low-frequency calls of mysticete whales that range from tens of hertz to several kilohertz and have source levels of 150–200 dB re 1 µPa (Cummings & Thompson, 1971; Edds-Walton, 1997; Širović et al., 2007; Stimpert et al., 2007; Wartzok & Ketten, 1999). These calls most likely serve social functions such as mate attraction, but may serve an orientation function as well (Green, 1994; Green et al., 1994; Richardson et al., 1995). Humpback whales are a notable exception within the mysticetes, with some calls exceeding 10 kHz (Zoidis et al., 2008).

Odontocete cetaceans and marine carnivores use underwater communicative signals that, while not as low in frequency as those of many mysticetes, likely serve similar functions. These include tonal whistles in some odontocetes and the wide variety of barks, grunts, clicks, sweeps, and pulses of pinnipeds. Of additional note are the aerial vocalizations that are produced by pinnipeds, otters, and polar bears. Again, the acoustic characteristics of these signals are quite diverse among species, but can be generally classified as having dominant energy at frequencies below 20 kHz (Richardson et al., 1995; Wartzok & Ketten, 1999).

Odontocete cetaceans generate short-duration (50–200 µs), specialized clicks used in biosonar with peak frequencies between 10 and 200 kHz to detect, localize, and characterize underwater objects such as prey (Au, 1993; Wartzok & Ketten, 1999). These clicks are often more intense than other communicative signals, with reported source levels as high as 229 dB re 1 µPa peak-to-peak (Au et al., 1974). The echolocation clicks of high-frequency cetaceans (e.g., porpoises) are narrower in bandwidth (i.e., the difference between the upper and lower frequencies in a sound) and higher in frequency than those of mid-frequency cetaceans (Madsen et al., 2005; Villadsgaard et al., 2007).

In general, frequency ranges of vocalization lie within the audible frequency range for an animal (i.e., animals vocalize within their audible frequency range); however, auditory frequency range and vocalization frequencies do not perfectly align. The frequency range of vocalization in a species can therefore be used to infer some characteristics of their auditory system; however, caution must be taken when considering vocalization frequencies alone in predicting the hearing capabilities of species for which no data exist (i.e., mysticetes). It is important to note that aspects of vocalization and hearing sensitivity are subject to evolutionary pressures that are not solely related to detecting communication signals. For example, hearing plays an important role in detecting threats (e.g., (Deecke et al., 2002)), and high-frequency hearing is advantageous to animals with small heads in that it facilitates sound localization based on differences in sound levels at each ear (Heffner & Heffner, 1992). This may be partially responsible for the difference in best hearing thresholds and dominant vocalization frequencies in some species of marine mammals (e.g., Steller sea lions, (Mulsow & Reichmuth, 2010)).

6.4 ACOUSTIC STRESSORS

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sources, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council, 2003, 2005), there are many unknowns in assessing impacts, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al., 2007; Southall et al., 2007). Many other factors besides just 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 ways in which an acoustic exposure could result in immediate effects or long-term consequences for an animal are explained in Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities). The following Background section discusses what is currently known about acoustic effects to marine mammals. These effects could hypothetically extend from physical injury or trauma to a behavioral or stress response that may or may not be detectable. Injury (physical trauma) can occur to organs or tissues of an animal (Section 6.4.1.1, Injury). Hearing loss (Section 6.4.1.2, Hearing Loss) is a noise-induced decrease in hearing sensitivity, which can be either temporary or permanent. Masking (Section 6.4.1.4, Masking) can occur when the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise). Physiological stress (Section 6.4.1.3, Physiological Stress) is an adaptive process that helps an animal cope with changing conditions; however, too much stress can potentially result in additional physiological effects. Behavioral response (Section 6.4.1.5, Behavioral Reactions) ranges from brief distractions to avoidance of a sound source to prolonged flight. Extreme behavioral or physiological responses can lead to stranding (Section 6.4.1.5, Behavioral Reactions). Long-term consequences (Section 6.4.1.7, Long-Term Consequences) are those impacts, or accumulation of impacts, that can result in decreases in individual fitness or population changes. To avoid or reduce potential impacts to the maximum extent practicable, the Navy will implement marine mammal mitigation measures during applicable training and testing activities that generate acoustic stressors (see Chapter 11, Mitigation Measures).

6.4.1 BACKGROUND

6.4.1.1 Injury

Injury (i.e., physical trauma) refers to the effects on the tissues or organs of an animal due to exposure to pressure waves. Injury due to exposure to non-explosive acoustic stressors such as sonar is discussed below. Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities) provides additional information on injury (e.g., physical trauma) and the framework used to analyze this potential impact.

Several mechanisms of acoustically induced tissue damage (non-auditory) have been proposed and are discussed below.

6.4.1.1.1 Injury due to Sonar-Induced Acoustic Resonance

An object exposed to its resonant frequency will tend to amplify its vibration at that frequency, a phenomenon called acoustic resonance. Acoustic resonance has been proposed as a mechanism by

which a sonar or sources with similar operating characteristics could damage tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to investigate the potential for acoustic resonance to occur in marine mammals (National Oceanic and Atmospheric Administration, 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding. The conclusions of the group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding in 2000. The frequency at which resonance was predicted to occur in the animals' lungs was 50 hertz (Hz), well below the frequencies used by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the unrealistic scenario in which air volumes would be undamped (unrestrained) by surrounding tissues and the amplitude of the resonant response would be greatest. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance would not occur under realistic conditions during training and testing activities, and this type of impact is not considered further in this analysis.

6.4.1.1.2 Nitrogen Decompression

Marine mammals are thought to deal with nitrogen loads in their blood and other tissues, caused by gas exchange from the lungs under conditions of high ambient pressure during diving, through anatomical, behavioral, and physiological adaptations (Hooker et al., 2012).

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses have been hypothesized to 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"). Bernaldo de Quiros et al. (2019) provide a recent review of theories of decompression sickness in beaked whales. The process has been under debate in the scientific community (Hooker et al., 2012; Saunders et al., 2008), although analyses of bycaught and drowned animals have demonstrated that nitrogen bubble formation can occur in animals that no longer exchange gas with the lungs (drowned) and which are brought to the surface, where tissues become supersaturated with nitrogen due to the reduction in hydrostatic pressure (Bernaldo de Quiros et al., 2013b; Moore et al., 2009). Deep-diving whales, such as beaked whales, have been predicted to have higher nitrogen loads in body tissues for certain modeled changes in dive behavior, which might make them more susceptible to decompression sickness (Fahlman et al., 2014b; Fernandez et al., 2005; 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., 2005; Jepson et al., 2003). However, modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer & Tyack, 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al., 2005; Jepson et al., 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Aguilar de Soto et al., 2006; Hooker et al., 2012; Tyack et al., 2006; Zimmer & 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). 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 et al. (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.

Still, little is known about respiratory physiology of deep-diving breath-hold animals. Costidis and Rommel (2016) suggest that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes below the depth of lung collapse, if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins, contributing to tissue gas loads. Researchers have also considered the role of carbon dioxide accumulation 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 & 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). 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 might 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 Fernández et al. (2005) 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. Although rare, similar findings have been found in the Risso's dolphin, another deep-diving species, but with presumably non-anthropogenic causes (Fernandez et al., 2017).

Dennison et al. (2012) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the livers 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 was unique to a small number of strandings associated with certain high intensity sonar events; the phenomenon has not been observed to the same degree in other stranded marine mammals, including other beaked whale strandings not associated with sonar use. Thus, it is uncertain as to whether there is some more easily triggered 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). Nevertheless, based on the rarity of observations of bubble pathology, the potential for nitrogen decompression sickness, or "the bends," is considered discountable.

6.4.1.1.3 Acoustically Induced Bubble Formation due to Sonars

A suggested cause of injury to marine mammals is rectified diffusion (Crum & Mao, 1996), the process of increasing the size of a microscopic gas bubble by exposing it to a sound field. The process is dependent upon a number of factors, including the sound pressure level (SPL) and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent they become emboli or cause localized tissue trauma, (2) bubbles develop to the extent that a complement 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 lung without negative consequence to the animal.

Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by marine mammals can cause the blood and some tissues to become supersaturated (Ridgway & Howard, 1979). The dive patterns of some marine mammals (e.g., beaked whales) are predicted to induce greater supersaturation (Houser et al., 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar pulses would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of supersaturated tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough time for bubbles to become a problematic size. The phenomena of bubble growth due to a destabilizing exposure was shown by Crum et al. (2005) by exposing highly supersaturated ex vivo bovine tissues to a 37 kHz source at 214 dB re 1 µPa. Although bubble growth occurred under the extreme conditions created for the study, these conditions would not exist in the wild because the levels of tissue supersaturation in the study (as high as 400–700 percent) are substantially higher than model predictions for marine mammals (Fahlman et al., 2009; Fahlman et al., 2014b; Houser et al., 2001; Saunders et al., 2008), and such high exposure level would only occur in very close proximity to the most powerful sonars. It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings.

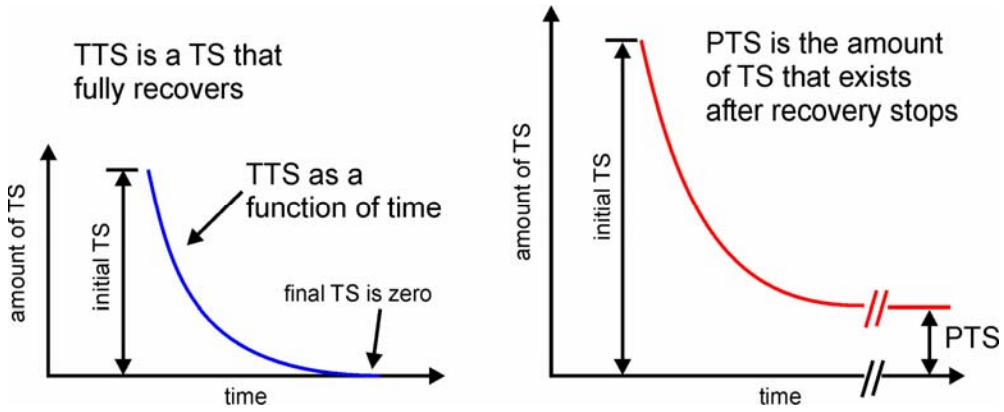
There has been considerable disagreement among scientists as to the likelihood of this phenomenon (Evans & Miller, 2003; Piantadosi & Thalmann, 2004). Although it has been argued that traumas from beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al., 2005; Jepson et al., 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Bernaldo de Quiros et al., 2012; Bernaldo de Quiros et al., 2013a; Bernaldo de Quiros et al., 2013b; Dennison et al., 2012; Moore et al., 2009).

6.4.1.2 Hearing Loss

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received sound pressure level, temporal pattern, and duration. The frequencies affected by hearing loss will vary depending on the frequency of the fatiguing noise, with frequencies at and above the noise frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative.

Hearing loss is typically quantified in terms of threshold shift (TS)—the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of TS measured usually decreases with increasing recovery time—the amount of time that has elapsed since a noise exposure. If the TS eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is called a temporary threshold shift (TTS). If the TS does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining TS is called a permanent threshold shift (PTS). Figure 6-3 shows two hypothetical TSs: one that completely recovers, a TTS; and one that does not completely recover, leaving some PTS. By definition, TTS is a function of the recovery time, therefore comparing the severity of noise exposures based on the amount of induced TTS can only be done if the recovery times are also taken into account. For example, a 20 dB TTS measured 24 hours post-exposure indicates a more hazardous exposure than one producing 20 dB of TTS measured only two minutes after exposure; if the TTS is 20 dB after 24 hours, the TTS measured after two minutes would likely be much higher. Conversely, if 20 dB of TTS was measured after two minutes, the TTS measured after 24 hours would likely be much smaller.

Studies have revealed that intense noise exposures may also cause auditory system injury that does not result in PTS (i.e., hearing thresholds return to normal after the exposure, but there is injury nonetheless). Kujawa and Liberman (2009) found that noise exposures sufficient to produce a TTS of 40 dB, measured 24 hours post-exposure using electro-physiological methods, 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, that a TTS in auditory evoked potential of up to approximately 50 dB, measured 24 hours post-exposure, resulted in neural degeneration. These studies demonstrate that PTS should not be used as the sole indicator of auditory injury, since exposures producing high levels of TTS (40–50 dB measured 24 hours after exposure)—but no PTS—may result in auditory injury.



Notes: TTS = temporary threshold shift, TS = threshold shift, PTS = permanent threshold shift

Figure 6-3: Two Hypothetical Threshold Shifts

There are no simple functional relationships between TTS and the occurrence of PTS or other auditory injury (e.g., neural degeneration). However, TTS and PTS are, by definition, mutually exclusive: an exposure that produces TTS cannot also produce PTS in the same individual; conversely, if an initial threshold shift only partially recovers, resulting in some amount of 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 would result in PTS or other injury also increases. Exposure thresholds for the occurrence of PTS or other auditory injury can therefore be defined based on a specific amount of TTS (i.e., although an exposure has been shown to produce only TTS, we assume that any additional exposure may result in some PTS or other injury). The specific upper limit of TTS is based on experimental data showing amounts of TTS that have not resulted in PTS or injury. In other words, we do not need to know the exact functional relationship between TTS and PTS or other injury, we only need to know the upper limit for TTS before some PTS or injury is possible.

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40–50 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; Miller et al., 1963; Ward et al., 1958; Ward et al., 1959; Ward, 1960). It is reasonable to assume the same relationship would hold for marine mammals, since there are many similarities between the inner ears of marine and terrestrial mammals, and experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, drug-induced hearing loss, masking, and frequency selectivity (Finneran et al., 2005a; Finneran, 2015; Ketten, 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately four minutes after exposure represent the limit of a non-injurious exposure (i.e., higher level exposures have the potential to cause auditory injury). Exposures sufficient to produce a TTS of 40 dB, measured approximately four minutes after exposure, therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS or other auditory injury, such as the delayed neural degeneration identified by 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 marine mammals (see Finneran, 2015). In these studies, hearing thresholds were measured in marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds

was then used to determine the amount of TTS at various post-exposure times. The major findings from these studies include the following:

- The method used to test hearing may affect the resulting amount of measured TTS, with neurophysiological measures producing larger amounts of TTS compared to psychophysical measures (Finneran et al., 2007; Finneran, 2015).
- The amount of TTS varies with the hearing test frequency. As the exposure SPL increases, the frequency at which the maximum TTS occurs also increases (Kastelein et al., 2014b). For high-level exposures, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al., 2007; Mooney et al., 2009a; Nachtigall et al., 2004; Popov et al., 2011; Popov et al., 2013; Schlundt et al., 2000). The overall spread of TTS from tonal exposures can therefore extend over a large frequency range (i.e., narrowband exposures can produce broadband [greater than one octave] TTS).
- The amount of TTS increases with exposure SPL and duration and is correlated with sound exposure level (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, however, 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 et al., 2010a, 2010b; Kastak et al., 2005; Mooney et al., 2009a). This means if two exposures have the same SEL but different durations, the exposure with the longer duration (thus lower SPL) will tend to produce more TTS than the exposure with the higher SPL and shorter duration. In most acoustic impact assessments, the scenarios of interest involve shorter duration exposures than the marine mammal experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.
- The amount of TTS depends on the exposure frequency. Sounds at low frequencies, well below the region of best sensitivity, are less hazardous than those at higher frequencies, near the region of best sensitivity (Finneran & Schlundt, 2013). The onset of TTS—defined as the exposure level necessary to produce 6 dB of TTS (i.e., clearly above the typical variation in threshold measurements)—also varies with exposure frequency. At low frequencies onset-TTS exposure levels are higher compared to those in the region of best sensitivity.
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al., 2010b; Kastelein et al., 2014d; Kastelein et al., 2015b; Mooney et al., 2009b). This means that TTS predictions based on the total, cumulative SEL will overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., ~40 dB) may require several days for recovery. Under many circumstances TTS recovers linearly with the logarithm of time (Finneran et al., 2010a, 2010b; Finneran & Schlundt,

2013; Kastelein et al., 2012a; Kastelein et al., 2012b; Kastelein et al., 2013a; Kastelein et al., 2014b; Kastelein et al., 2014c; Popov et al., 2011; Popov et al., 2013; Popov et al., 2014). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., 6 dB recovery per doubling of time).

Nachtigall et al. (2018) and Finneran (2018) describe the measurements of hearing sensitivity of multiple odontocete species (bottlenose dolphin, harbor porpoise, beluga, and false killer whale) when a relatively loud sound was preceded by a warning sound. These captive animals were shown to reduce hearing sensitivity when warned of an impending intense sound. Based on these experimental observations of captive animals, the authors suggest that wild animals may dampen their hearing during prolonged exposures or if conditioned to anticipate intense sounds. Finneran recommends further investigation of the mechanisms of hearing sensitivity reduction in order to understand the implications for interpretation of some existing temporary threshold shift data obtained from captive animals, notably for considering TTS due to short duration, unpredictable exposures. No modification of analysis of auditory impacts is currently suggested, as the Phase III auditory impact thresholds are based on best available data for both impulsive and non-impulsive exposures to marine mammals.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of human-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. These include some sonars and other transducers and impulsive sound sources such as air guns and impact pile driving. Neither air guns nor impact pile driving will be used as part of training and testing activities being covered in this request for LOAs.

6.4.1.2.1 Threshold Shift due to Sonar and Other Transducers

TTS in mid-frequency cetaceans exposed to non-impulsive sound has been investigated in multiple studies (Finneran et al., 2005b; Finneran et al., 2010a; Finneran & Schlundt, 2013; Mooney et al., 2009a; Mooney et al., 2009b; Nachtigall et al., 2003; Nachtigall et al., 2004; Popov et al., 2013; Popov et al., 2014; Schlundt et al., 2000) of two species, bottlenose dolphins and beluga whales. Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al., 2012b) and the finless porpoise (*Neophocaena phocaenoides*) (Popov et al., 2011). TTS from non-impulsive sounds has also been investigated in three pinniped species: harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), and northern elephant seal (*Mirounga angustirostris*) (e.g., Kastak et al., 2005; Kastelein et al., 2012a). These data are reviewed in detail in Finneran (2015), as well as the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (U.S. Department of the Navy, 2017b), and the major findings are summarized above. Several studies of threshold shift in marine mammals exposed to non-impulsive sounds have been published since development of the technical report. Kastelein et al. (2017) examined threshold shift in harbor porpoises exposed to 3.5 – 4.1 kHz sonar playbacks. The results are consistent with the Navy's threshold shift criteria for high frequency cetaceans.

6.4.1.3 Physiological Stress

The growing field of conservation physiology relies in part on the ability to monitor stress hormones in populations of animals, particularly those that are threatened or endangered. The ability to make predictions from stress hormones about impacts on individuals and populations exposed to various forms of stressors, natural and human-caused, relies on understanding the linkages between changes in stress hormones and resulting physiological impacts. At this time, the sound characteristics that correlate with specific stress responses in marine mammals are poorly understood, as are the ultimate

consequences due to these changes. Navy-funded efforts are underway to try to improve the understanding of and the ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; New et al., 2013b; Pirotta et al., 2015a). With respect to acoustically induced stress, this includes not only determining how and to what degree various types of anthropogenic sound cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the mammal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether they are naïve or experienced with the sound (e.g., prior experience with a stressor may result in a reduced response due to habituation (Finneran & Branstetter, 2013; St. Aubin & Dierauf, 2001). Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, the Navy assumes in its effect analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to disease and naturally occurring toxins, lack of prey availability, and interactions with predators all contribute to the stress a marine mammal experiences (Atkinson et al., 2015). Breeding cycles, periods of fasting, social interactions with members of the same species, and molting (for pinnipeds) are also stressors, although they are natural components of an animal's life history. Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally (Fair et al., 2014; Meissner et al., 2015; Rolland et al., 2012). Anthropogenic stressors potentially include such things as fishery interactions, pollution, tourism, 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 & Mench, 2000). However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). The generalized stress response is classically characterized by the release of cortisol, a hormone that has many functions, including elevation of blood sugar, suppression of the immune system, and alteration of the biochemical pathways that affect fat, protein, and carbohydrate metabolism. However, it is now known that the endocrine response (glandular secretions of hormones into the blood) to a stressor can extend to other hormones. For instance, thyroid hormones can also vary under the influence of certain stressors, particularly food deprivation. These types of responses typically occur on the order of minutes to days. The "fight or flight" response, an acute stress response, is characterized by the very rapid release of hormones that stimulate glucose release, increase heart rate, and increase oxygen consumption.

What is known about the function of the various stress hormones is based largely upon observations of the stress response in terrestrial mammals. The endocrine response of marine mammals to stress may not be the same as that of terrestrial mammals because of the selective pressures marine mammals faced during their evolution in an ocean environment (Atkinson et al., 2015). For example, due to the necessity of breath-holding while diving and foraging at depth, the physiological role of the epinephrine and norepinephrine (the catecholamines) in marine mammals might be different than in other 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 pronounced increase in response to handling stress (St. Aubin & Dierauf, 2001; St. Aubin & Geraci, 1989).

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al., 1990b) 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) and was likely of little biological significance with respect to mitigating stress. 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, in this study, it cannot be determined 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). Spectral analysis of heart rate variability corroborated direct measures of heart rate (Bakhchina et al., 2017). This response might have been due in part to the conditions during testing, the young age of the animal, and the novelty of the exposure; a year later the exposure was repeated at a slightly higher received level and there was no heart rate response, indicating the beluga whale had potentially habituated to the noise exposure. 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 vs. 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) observed a rapid but short-lived decrease in heart rates in harbor and grey seals exposed to seismic air guns (cited in Gordon et al., 2003). Williams et al. (2017) monitored the heart rates of narwhals released from capture and found that a profound dive bradycardia persisted, even though exercise effort increased dramatically as part of their escape response following release. Thus, although some limited evidence suggests that tachycardia might occur as part of the acute stress response of animals that are at the surface, the bradycardia typical of diving in marine mammals appears to be dominant to any stress-related tachycardia and might even be enhanced in response to an acute stressor.

Whereas a limited amount of work has addressed the potential for acute sound exposures to produce a stress response, almost nothing is known about how chronic exposure to acoustic stressors affects stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably the only study of chronic noise exposure associating changes in a stress hormone with changes in anthropogenic noise, Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of

September 11, shipping was significantly reduced in the region where fecal collections were made and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al., 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (Bain, 2002; Erbe, 2002; Lusseau, 2006; Noren et al., 2009; Pirotta et al., 2015b; Read et al., 2014; Rolland et al., 2012; Williams et al., 2006; Williams et al., 2009; Williams et al., 2014a; Williams et al., 2014b). 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 measures 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. Nevertheless, although the reduced presence of the ships themselves cannot be ruled out as potentially contributing to the reduction in fecal cortisol metabolites in North Atlantic right whales, and there are potential issues in pseudoreplication and study design, the work of Rolland et al. (2012) represents the most provocative link between ocean noise and cortisol in cetaceans to date.

Navy-funded efforts are underway to try and improve our understanding and ability to predict how stressors ultimately affect marine mammal populations (King et al., 2015; e.g., New et al., 2013a; New et al., 2013b; Pirotta et al., 2015a), and whether they are naïve or experienced with the sound (e.g., prior experience with a stressor) may result in a reduced response due to habituation (St. Aubin & Dierauf, 2001).

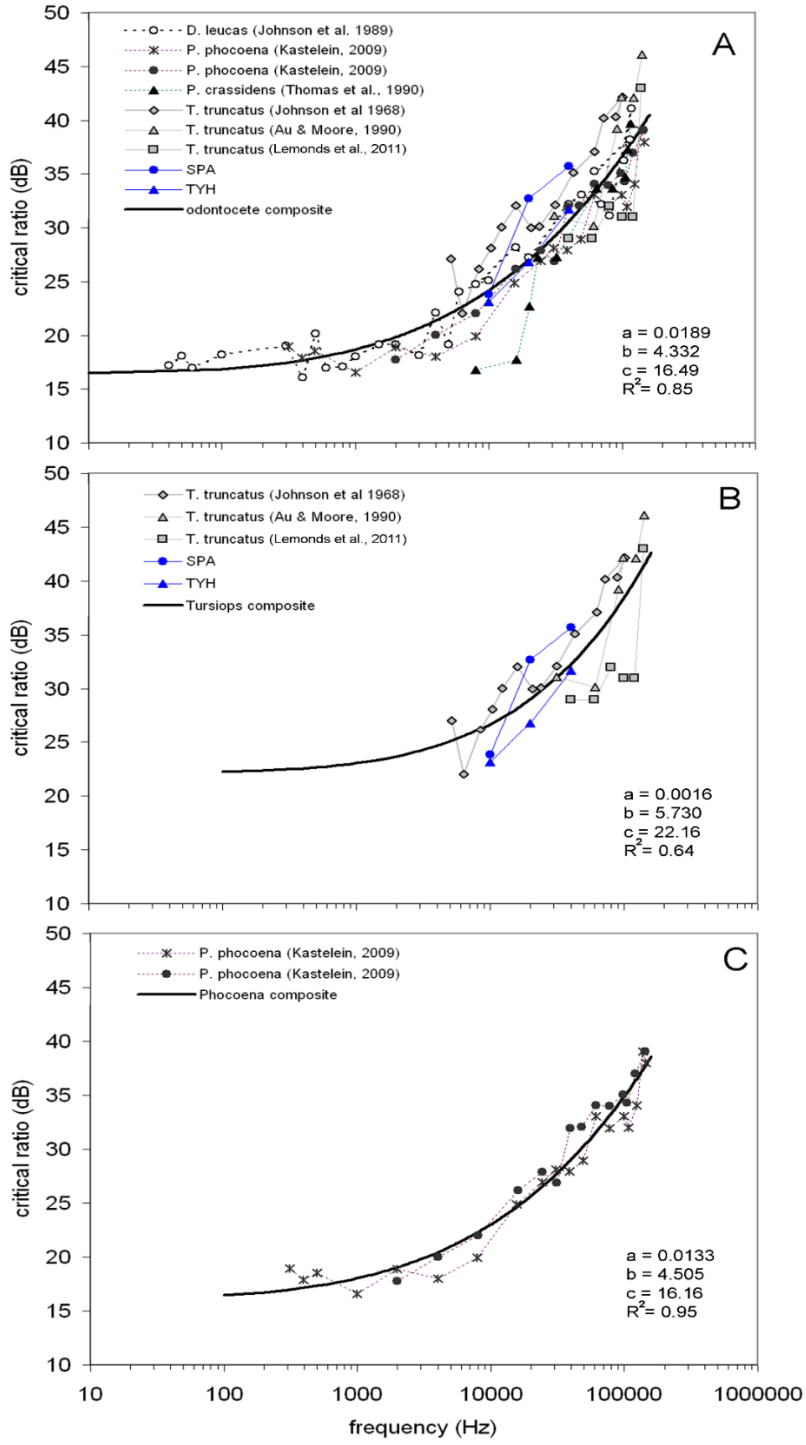
6.4.1.4 Masking

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 decibels an auditory detection, discrimination, or recognition threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal (e.g., Lombard effect, or 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).

Critical ratios are the lowest signal-to-noise ratio in which detection occurs (Finneran & Branstetter, 2013; Johnson et al., 1989; Southall et al., 2000). When expressed in dB, critical ratios can easily be calculated by subtracting the noise level (in dB re 1 $\mu Pa^2/Hz$) from the signal level (in dB re 1 µPa) at threshold. Critical ratios have been measured for pinnipeds (Southall et al., 2000, 2003), odontocetes (Figure 6-4) (Au & Moore, 1990; Johnson et al., 1989; Kastelein & Wensveen, 2008; Lemonds et al., 2011; Thomas et al., 1990a), and sea otters (Ghoul & Reichmuth, 2014). Critical ratios are directly related to the bandwidth of auditory filters and as a result, critical ratios increase as a function of signal frequency (Au & Moore, 1990; Lemonds et al., 2011). Higher-frequency noise is more effective at

masking higher frequency signals. Composite critical ratio functions have been estimated for odontocetes (Figure 6-4), which allow predictions of masking if the spectral density of noise is known (Branstetter et al., 2017b). Although critical ratios are typically estimated in controlled laboratory conditions using Gaussian (white) noise, critical ratios can vary considerably (see Figure 6-5) depending on the noise type (Branstetter et al., 2013; Trickey et al., 2010). When broadband noise is coherently amplitude modulated, a considerable release from masking will occur known as comodulation masking release (Branstetter & Finneran, 2008; Branstetter et al., 2013). Signal type (e.g., whistles, burst-pulse, sonar clicks) and spectral characteristics (e.g., frequency modulation and / or harmonics) may further influence masked detection thresholds (Branstetter et al., 2016; Cunningham et al., 2014).

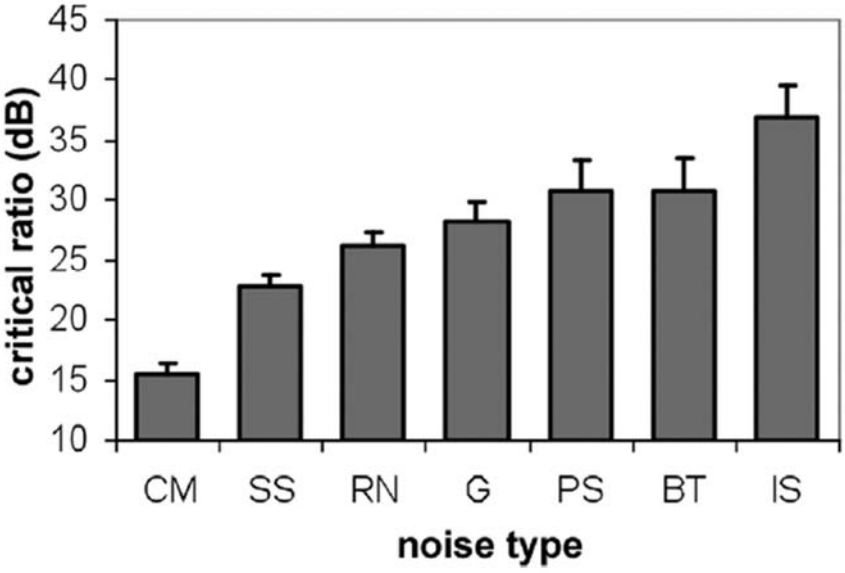
Clark et al. (2009) developed a model for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, the model estimates that a right whale's optimal communication space (around 20 km) is decreased by 84 percent when two commercial ships pass through it. Similarly, Aguilar de 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. This 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 (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, noise-source location, distance relative to each other, and received level of the call.



Source: Branstetter et al. (2017)

Notes: (A) Odontocete critical ratios and composite model: CR = $a[\log_{10}(f)]^b + c$, where *a, b,* and *c* are model coefficients and *f* is the signal frequency in Hz. Equation 1 was fit to aggregate data for all odontocetes. (B) *T. truncatus.* critical ratios and composite model. (C) *P. phocoena.* critical ratios and composite model. Parameter values for composite models are displayed in the lower right of each panel.

Figure 6-4: Odontocete Critical Ratios



Source: Branstetter et al. (2013)
Notes: CM =Comodulated, SS = snapping shrimp, RN = rain noise, G = Gaussian, PS = pile saw, BT = boat engine noise, IS = ice squeaks

Figure 6-5: Critical Ratios for Different Noise Types

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes 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 & Parks, 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (Gordon et al., 2003; Holt et al., 2008; Holt et al., 2011; Lesage et al., 1999; McDonald et al., 2009; 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 persistent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen & Parks, 2016). Model simulation suggests that the frequency shift resulted in 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 & 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 quieter location, or reducing self-noise from hydrodynamic flow by remaining still.

6.4.1.4.1 Informational Masking

Much emphasis has been placed on signal detection in noise, and as a result, most masking studies and communication space models have focused on masked detection thresholds. However, from a fitness perspective, signal detection is almost meaningless without the ability to determine the sound source location and recognize "what" is producing the sound. Marine mammals use sound to recognize conspecifics, prey, predators, or other biologically significant sources (Branstetter et al., 2016). Masked recognition thresholds (often called informational masking) for whistle-like sounds have been measured for bottlenose dolphins (Branstetter et al., 2016) and are approximately 4 dB above detection thresholds (energetic masking) for the same signals. It should be noted that the term "threshold" typically refers to the listener's ability to detect or recognize a signal 50 percent of the time. For example, human speech communication where only 50 percent of the words are recognized would result in poor communication (Branstetter et al., 2016). Likewise, recognition of a conspecific call or the acoustic signature of a predator at only the 50 percent level could have severe negative impacts. If "quality communication" is arbitrarily set at 90 percent recognition (which may be more appropriately related to animal fitness), the output of communication space models (which are based on 50 percent detection) would likely result in a significant decrease in communication range (Branstetter et al., 2016).

Marine mammals use sound to recognize predators (Allen et al., 2014; Cummings & Thompson, 1971; Curé et al., 2015; Fish & Vania, 1971). Auditory recognition 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 recognition of predator cues are impeded. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by mammal-eating killer whales. The seals acoustically discriminate between the calls of mammal-eating and fish-eating 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.

6.4.1.4.2 Masking by Sonar and Other Transducers

Masking by low-frequency or mid-frequency active sonar with relatively low-duty cycles is unlikely for most cetaceans and pinnipeds as sonar signals occur over a relatively short duration, and narrow bandwidth that does not overlap with vocalizations for most marine mammal species. While dolphin whistles and mid-frequency active sonar are similar in frequency, masking is unlikely due to the low-duty cycle of most sonars. Low-frequency active sonar could also 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 continuously active sonars have more potential to mask vocalizations, particularly for delphinids and other mid-frequency cetaceans. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high-frequency acoustic sources such as pingers that operate at higher repetition rates (e.g., 2–10 kHz with harmonics up to 19 kHz, 76 to 77 pings per minute (Culik et al., 2001)), also operate at

lower source levels. While the lower source levels of these systems limits the range of impact compared to more traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high duty cycle systems operate overlaps the vocalization frequency of a number of mid-frequency cetaceans. Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically mediated cooperative behaviors such as foraging or reproductive activities. Similarly, because the systems are mid-frequency, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g., killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high duty cycle sonars on marine mammals, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g., vessel noise and low-frequency cetaceans), and will likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm & Slabbekoorn, 2005; Hotchkin & Parks, 2013) and behavioral impacts such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al., 2003). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al., 2004; Parks et al., 2007), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm & Slabbekoorn, 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm & Slabbekoorn, 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al., 2003).

6.4.1.5 Behavioral Reactions

As discussed in the Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities), any stimulus in the environment can cause a behavioral response in marine mammals. These stimuli include noise from anthropogenic sources such as vessels, sonar, or aircraft but could also include the physical presence of a vessel or aircraft. However, stimuli such as the presence of predators, prey, or conspecifics could also influence how or if a marine mammal responds to a sound. Furthermore, the response of a marine mammal to an anthropogenic sound may depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al., 2011). The distance from the sound source and whether it is approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al., 2003).

For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson et al. (1995). 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 marine mammal(s) was known or could be estimated, and also examined the role of context. Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. 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. (2011) outlined an approach to assessing the effects of sound on marine mammals that incorporates these contextual-based factors. They recommend considering not just the received level of sound, but also in what activity the animal is engaged, the nature and novelty of the sound (i.e., is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context,"

as described, greatly influences the type of behavioral response exhibited by the animal (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b). Forney et al. (2017) also point out that an apparent lack of response (e.g., no displacement or avoidance of a sound source) may not necessarily mean there is no cost to the individual or population, as some resources or habitats may be of such high value that animals may choose to stay, even when experiencing stress or hearing loss. Forney et al. (2017) recommend considering both the costs of remaining in an area of noise exposure such as TTS, PTS, or masking, which could lead to an increased risk of predation or other threats or a decreased capability to forage, and the costs of displacement, including potential increased risk of vessel strike or bycatch, increased risks of predation or competition for resources, or decreased habitat suitable for foraging, resting, or socializing.

Behavioral reactions could result from a variety of sound sources such as sonar and other active acoustic sources (e.g., pingers), vessel noise, and aircraft noise. There are data on the reactions of some species in different behavioral states, providing evidence on the importance of context in gauging a behavioral response. However, for most species, little or no data exist on behavioral responses to any sound source, and so all species have been grouped into broad taxonomic groups from which general response information can be inferred (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b).

6.4.1.5.1 Behavioral Reactions to Sonar and other Transducers

Sonar and other transducers can range in frequency from less than 1 kHz (e.g., low-frequency active sonar) to over 200 kHz (e.g., fish finders), with duty cycles that range from one ping per minute to an almost continuous sound. Although very high-frequency sonars are out of the hearing range of most marine mammals, some of these sources may contain artifacts at lower frequencies that could be detected (Deng et al., 2014; Hastie et al., 2014). High duty-cycle sonar systems operate at lower source levels, but with a more continuous sound output. These sources can be stationary or on a moving platform, and there can be more than one source present at a time. Guan et al. (2017) also found that sound levels in the mid-frequency sonar bandwidth remained elevated at least 5 dB above background levels for the first 7–15 seconds (within 2 km) after the emission of a sonar ping; depending on the length of the sonar ping and the inter-ping interval, this reverberation could increase cumulative SEL estimates during periods of active sonar. This variability in parameters associated with sonar and other transducers makes the estimation of behavioral responses to these sources difficult, with observed responses ranging from no apparent change in behavior to more severe responses that could lead to some costs to the animal. As discussed in this request for authorization in Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities) and Section 6.4.1.5 (Behavioral Reactions), 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.

In order to explore this complex question, behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, United States (off Southern California), Mediterranean, Australian, and Norwegian waters. These studies have attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to understand better their potential impacts. 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 1–8 km. Some of these studies have suggested that ramping up a source from a lower source level would act as a mitigation measure to protect against higher order (e.g., TTS or PTS) impacts of some active sonar sources; however, this practice may only be effective for more responsive animals, and for short durations (e.g., 5 minutes) of ramp up (von Benda-Beckmann et al., 2014; von Benda-Beckmann et al., 2016). Therefore, while these studies have provided the most information to date on behavioral responses of marine mammals to sonar, there are still many contextual factors to be teased apart, and determining what might produce a significant behavioral response is not a trivial task. Additional information about active sonar ramp-up procedures, including why the Navy will not implement them as mitigation under the Proposed Action, is provided in Section 11.1.2.1 (Active Sonar).

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 & Richlen, 2015; Henderson et al., 2016; Manzano-Roth et al., 2016; Martin et al., 2015; McCarthy et al., 2011; Mobley & Deakos, 2015; Moretti et al., 2014; Tyack et al., 2011). In addition, extensive aerial, visual, and passive acoustic monitoring have been conducted before, during, and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Farak et al., 2011; HDR, 2011; Norris et al., 2012; Smultea & Mobley, 2009; Smultea et al., 2009; Trickey et al., 2015; U.S. Department of the Navy, 2011c, 2013a, 2014a, 2015a). During all of these monitoring efforts, very few behavioral responses were observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed but typically before the event or appeared to have been deceased prior to the event; e.g., Smultea et al., 2011). While passive acoustic studies are limited to detections of vocally active marine mammals, and visual studies are limited to what can be observed at the surface, these study types have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies. Furthermore, when visual and passive acoustic data collected during a training event are combined with ship movements and sonar use, and with tagged animal data when possible, they provide a unique and realistic scenario for analysis, as in (Falcone et al., 2017), (Manzano-Roth et al., 2016), or (Baird et al., 2017b). In addition to these types of observational behavioral response studies, Harris & 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 (smaller sized and deployed at closer proximity) sources, on wild animals with both scaled and real but directed sources, and predator playback studies, all of which will be discussed below.

The above behavioral response studies and observations have been conducted on a number of mysticete and odontocete species, which can be extrapolated to other similar species in these taxonomic groups. No field studies of pinniped behavioral responses to sonar have been conducted; however, there are several captive studies on some pinniped and odontocete species that can provide insight into how these animals may respond in the wild. The captive studies typically represent a more controlled approach, which allow researchers to better estimate the direct impact of the received level of sound leading to behavioral responses, and to potentially link behavioral to physiological responses. However, there are still contextual factors that must be acknowledged, including previous training to complete tasks and the presence of food rewards upon completion. There are no corresponding captive

studies on mysticete whales; therefore, some of the responses to higher level exposures must be extrapolated from odontocetes.

6.4.1.5.1.1 Mysticetes

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; Sivle et al., 2015). Similarly, while the rates of foraging lunges decreased in humpback whales due to sonar exposure, there was variability in the response across individuals, with one animal ceasing to forage completely and another animal starting to forage during the exposure (Sivle et al., 2016). In addition, lunges decreased (although not significantly) during a no-sonar control vessel approach prior to the sonar exposure, and lunges decreased less during a second sonar approach than during the initial approach, possibly indicating some response to the vessel and some habituation to the sonar and vessel after repeated approaches. In the same experiment, most of the non-foraging humpback whales did not respond to any of the approaches (Sivle et al., 2016). These humpback whales also showed variable avoidance responses, as some animals avoided the sonar vessel during the first exposure but not the second, while others avoided the sonar during the second exposure, and only one avoided both. In addition, almost half of the animals that avoided the sonar vessel were foraging before the exposure; the animals that avoided the sonar vessel while not feeding responded at a slightly lower received level and greater distance than those that were feeding (Wensveen et al., 2017). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. In fact, when the prey field was mapped and used as a covariate in similar models looking for a response in blue whales, the response in deep-feeding behavior by blue whales was even more apparent, reinforcing the need for contextual variables to be included when assessing behavioral responses (Friedlaender et al., 2016). However, even when responses did occur the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al., 2013; Sivle et al., 2015). In another study, humpback whales exposed to a 3 kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al., 2014). However, 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 to protect 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^2s), the frequency, duration, and temporal pattern of signal presentation were different.

Humpback whales in another behavioral response experiment in Australia also responded to a 2 kHz tone stimulus by changing their course during migration to move more offshore and surfaced more frequently, but otherwise did not respond (Dunlop et al., 2013). Humpback whales in the 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; 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 (Mobley & Milette, 2010; Mobley, 2011; Mobley & Pacini, 2012; Mobley et al., 2012; Smultea et al., 2009). In fact, 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 (U.S. Department of the Navy, 2011b). 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 pec slaps, tail slaps and breaches; however, these are very common behaviors in competitive pods during the breeding season and were not considered to have occurred in response to the sonar (Mobley et al., 2012).

The strongest baleen whale response in any behavioral response study was observed in a minke whale in the 3S2 study, which responded at 146 dB re 1 µPa by strongly avoiding the sound source (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 the Southern California BRS study also responded by increasing its directional movement, but maintained its speed and dive patterns, and so did not demonstrate as strong of a response (Kvadsheim et al., 2017). In addition, the 3S2 minke whale demonstrated some of the same avoidance behavior during the controlled ship approach with no sonar, indicating at least some of the response was to the vessel (Kvadsheim et al., 2017). Martin et al. (2015) found that the density of calling minke whales was reduced during periods of Navy training involving sonar relative to the periods before training, and increased again in the days after training was completed. The responses of individual whales could not be assessed, so in this case it is unknown whether the decrease in calling animals indicated that the animals left the range, or simply ceased calling. Similarly, minke whale detections made using Marine Acoustic Recording Instruments off Jacksonville, FL, were reduced or ceased altogether during periods of sonar use (Norris et al., 2012; U.S. Department of the Navy, 2013a), especially with an increased ping rate (Charif et al., 2015). Two minke whales also stranded in shallow water after the U.S. Navy training event in the Bahamas in 2000, although these animals were successfully returned to deep water with no physical examinations, therefore, no final conclusions were drawn on whether the sonar led to their stranding (Filadelfo et al., 2009a; Filadelfo et al., 2009b; U.S. Department of Commerce & U.S. Department of the Navy, 2001).

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 1997–1998 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 although received levels were similar (Clark & 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 & Clark, 2000).

Opportunistic passive acoustic-based studies have also detected behavioral responses to sonar, although definitive conclusions are harder to draw. 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 110–120 dB re 1 µPa (Melcón et al., 2012); however, without visual observations it is unknown whether there was another factor that contributed to the reduction in foraging calls, such as the presence of conspecifics. In another example, Risch et al. (2012) determined that humpback whale song produced in the Stellwagen Bank National Marine Sanctuary was reduced, and since the timing was concurrent with an Ocean Acoustic Waveguide Remote Sensing experiment occurring 200 km away, they concluded that the reduced song was a result of the Ocean Acoustic Waveguide Remote Sensing. 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 Ocean Acoustic Waveguide Remote Sensing but could be explained by natural causes.

Although some strong responses have been observed in mysticetes to sonar and other active acoustic transducers (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 never be introduced in real Navy testing and training scenarios. While data are lacking 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 are likely to have similar responses to high duty cycle sonars. Therefore, mysticete behavioral responses to Navy sonar will likely be a result of the animal's behavioral state and prior experience rather than external variables such as ship proximity; thus, if significant behavioral responses occur they will likely be short term. In fact, no significant behavioral responses such as panic, stranding, or other severe reactions have been observed during monitoring of actual training exercises (Smultea et al., 2009; U.S. Department of the Navy, 2011c, 2014b; Watwood et al., 2012).

6.4.1.5.1.2 Odontocetes

Behavioral response studies have been conducted on odontocete species since 2007, with a focus on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge et al., 2009; Defence Science and Technology Laboratory,

2007; Manzano-Roth et al., 2013; McCarthy et al., 2011; Moretti et al., 2009; Southall et al., 2011; Southall et al., 2012; Southall et al., 2013; Southall et al., 2014; Southall et al., 2015; Tyack et al., 2011). Through analyses of these behavioral response studies, a preliminary overarching effect of greater sensitivity to most anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al., 2009).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, longer deep and shallow dive durations, and other unusual dive behavior (Boyd et al., 2008; Defence Science and Technology Laboratory, 2007; DeRuiter et al., 2013b; Miller et al., 2015; Southall et al., 2011; Stimpert et al., 2014; Tyack et al., 2011). A similar 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; although all of these exposures occurred within 1–8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few kilometers to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to 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 84–144 and 78–106 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., 2013b). 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 are shorter duration and randomly located; consequently, they 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 (6–25 km in this study). Watwood et al. (2017) found that helicopter-dipping events occurred more frequently but with shorter durations than periods of hull-mounted sonar, and also found that the longer the duration of a sonar event, the greater reduction in detected Cuvier's beaked whale group dives. Therefore, when looking at the number of detected group dives, there was a greater reduction during periods of hull-mounted sonar than during helicopter-dipping sonar. Long-term tagging work has demonstrated that the longer duration dives considered a behavioral response by DeRuiter et al. (2013b) fell within the normal range of dive durations found for eight tagged Cuvier's beaked whales on the Southern California Offshore Range (Falcone et al., 2017; Schorr et al., 2014). However, the longer inter-deep dive intervals found by DeRuiter et al. (2013b), which were among the longest found by Schorr et al. (2014) and Falcone et al. (2017), could indicate a response to sonar. In addition, Williams et al. (2017) note that in normal deep dives or during fast swim speeds, beaked whales and other marine mammals use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described

in DeRuiter et al. (2013b), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expending on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams (2017) was higher.

On Navy ranges, Blainville's beaked whales located on the range appear to move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge et al., 2009; Manzano-Roth et al., 2016; Manzano-Roth et al., 2013; McCarthy et al., 2011; Moretti et al., 2009; Tyack et al., 2011). However, Blainville's beaked whales remain on the range to forage throughout the rest of the year (Henderson et al., 2016), possibly indicating that this a preferred foraging habitat regardless of the effects of the noise, or it could be that there are no long-term consequences of the sonar activity. Similarly, photo-identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years, with re-sightings up to seven years apart, indicating a possibly resident population on the range (Falcone et al., 2009; Falcone & Schorr, 2014).

Beaked whales may respond similarly to shipboard echosounders, commonly used for navigation, fisheries, and scientific purposes, with frequencies ranging from 12 to 400 kHz and source levels up to 230 dB re 1 µPa but typically a very narrow beam (Cholewiak et al., 2017). During a scientific cetacean survey, an array of echosounders was used in a one-day-on, one-day-off paradigm. Beaked whale acoustic detections occurred predominantly (96 percent) when the echosounder was off, with only four detections occurring when it was on. Beaked whales were sighted fairly equally when the echosounder was on or off, but sightings were further from the ship when the echosounder was on (Cholewiak et al., 2017). These findings indicate that the beaked whales may be avoiding the area and may cease foraging near the echosounder.

Tyack et al. (2011) 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., 2011). 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, 2012). Results varied, from no response by killer whales to an increase in group size and attraction to the source in pilot whales (Curé et al., 2012).

While there has been a focus on beaked whale responses to sonar, other species have been studied during behavioral response studies as well, including pilot whales, killer whales, and sperm whales. Responses by these species have also included horizontal avoidance, changes in behavioral state, and changes in dive behavior (Antunes et al., 2014; Miller et al., 2011; Miller, 2012; Miller et al., 2014). 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 1µPa) and sperm whales (mean 140 dB re 1µPa) than killer whales (mean 129 dB re 1µPa) (Antunes et al., 2014; Miller, 2012; Miller et al., 2014). A close examination of the tag data from the Norwegian groups showed that responses seemed to be

behaviorally or signal frequency mediated. For example, killer whales only changed their dive behavior when doing deep dives at the onset of 1–2 kHz sonar (sweeping across frequencies), but they did not change their dive behavior if they were deep-diving during 6–7 kHz sonar (sweeping across frequencies). Nor did they change their dive behavior if they were conducting shallow dives at the onset of either type of sonar. Similarly, pilot whales and sperm whales performed normal deep dives during 6–7 kHz sonar, while during 1–2 kHz sonar the pilot whales conducted fewer deep dives and the sperm whales performed shorter and shallower dives (Sivle et al., 2012b). In addition, pilot whales were also more likely to respond to lower received levels when non-feeding than feeding during 6–7 kHz sonar exposures, but were more likely to respond at higher received levels when non-feeding during 1–2 kHz sonar exposures. Furthermore, pilot whales exposed to a 38 kHz downward-facing echosounder did not change their dive and foraging behavior during exposure periods, although the animals' heading variance increased and fewer deep dives were conducted (Quick et al., 2017). In contrast, killer whales were more likely to respond to either sonar type when non-feeding than when feeding (Harris et al., 2015). These results again demonstrate that the behavioral state of the animal mediates the likelihood of a behavioral response, as do the characteristics (e.g., frequency) of the sound source itself.

Other responses during behavioral response studies included the synchronization of pilot whale surfacings with sonar pulses during one exposure, possibly as a means of mitigating the sound (Wensveen et al., 2015), and mimicry of the sonar with whistles by pilot whales (Alves et al., 2014), false killer whales (DeRuiter et al., 2013b) and Risso's dolphins (Smultea et al., 2012). In contrast, in another study melon-headed whales had "minor transient silencing" (a brief, non-lasting period of silence) after each 6–7 kHz signal, and (in a different oceanographic region) pilot whales had no apparent response (DeRuiter et al., 2013a). 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 on the probability of detecting sperm whale clicks (Charif et al., 2015; U.S. Department of the Navy, 2013b).

In addition, killer whale sighting data from the same region in Norway as the behavioral response study were 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; 2014; Baird et al., 2017a) 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 events. 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 and 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 a mean of 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 (Baird et al., 2013) 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 re1 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; National Marine Fisheries Service, 2005; U.S. Department of the Navy, 2003) 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" (National Oceanic and Atmospheric Administration Fisheries, 2014). Several odontocete species, including bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and leaving the area, and at the highest received levels animals were not present in the area at all (Henderson et al., 2014b). 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 & Schevill, 1975; Watkins et al., 1985). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

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 bow ride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (HDR, 2011; U.S. Department of the Navy, 2011b; Watwood et al., 2012). During small boat surveys near the 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 poor weather conditions in November that may have prevented animals from being seen (Campbell et al., 2010). There were also fewer passive acoustic dolphin detections during and after longer sonar activities in the Mariana 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, which transmit sound into the acoustic environment similar to Navy sources, have been used to deter marine mammals from fishing gear both to prevent entanglement and to reduce depredation (taking fish). These devices have been used successfully to deter harbor porpoises and beaked whales from getting entangled in fishing nets. For example, Kyhn et al. (2015) tested two types of pingers, one with a 10 kHz tone and one with a broadband 30−160 kHz sweep. Porpoise detection rates were reduced by 65 percent for the sweep and

40 percent for the tone, and while there was some gradual habituation after the first 2–4 exposures, longer-term exposures (over 28 days) showed no evidence of additional habituation. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins & Schevill, 1975). However, acoustic harassment devices used to deter marine mammals from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 μPa on a longline to prevent depredation by killer whales. Although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of marine mammal deterrents, Schakner & 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, simulate a predator, or are otherwise predictive of a threat are 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 net pingers may create a "dinner bell effect," where marine mammals have learned to associate the signal with the availability of prey (Jefferson & Curry, 1996; Schakner & Blumstein, 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales since 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 et al., 2008; Schakner & Blumstein, 2013). Similarly, a 12 kHz acoustic harassment device intended to scare seals was ineffective at deterring seals but effectively caused avoidance in harbor porpoises out to over 500 m from the source, highlighting different species- and device-specific responses (Mikkelsen et al., 2017). Additional behavioral studies have been conducted with captive harbor porpoises using acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al., 2006; Kastelein et al., 2001). 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) modeled the long-term, population-level impacts of fisheries bycatch, pinger deterrents, and time-area closures on a population of harbor porpoises. They found that when pingers were used alone (in the absence of gillnets or time-area closures), the animals were deterred from the area often enough to cause a population level reduction of 21 percent, greater even than the modeled level of current bycatch impacts. However, when the pingers were coupled with gillnets in the model, and time-area closures were also used (allowing a net- and pinger-free area for the porpoises to move into while foraging), the population only experienced a 0.8 percent decline even with current gillnet use levels. This demonstrates that, when used correctly, pingers can successfully deter porpoises from gillnets without leading to any negative impacts.

Controlled experiments have also been conducted on captive animals to estimate received levels at which behavioral responses occur. In one study, bottlenose dolphin behavioral responses were recorded when exposed to 3 kHz sonar-like tones between 115 and 185 dB re 1 μPa (Houser et al., 2013), and in another study bottlenose dolphins and beluga whales were presented with one-second tones up to 203 dB re 1 μPa to measure TTS (Finneran et al., 2001; Finneran et al., 2003a; Finneran & Schlundt, 2004; Finneran et al., 2005b; Schlundt et al., 2000). During these studies, responses included changes in respiration rate, fluke slaps, and a refusal to participate or return to the location of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al., 2002; Schlundt et al., 2000). In the behavioral response experiment, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over 10 trials. In the TTS study bottlenose dolphins exposed to one-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re

1 μPa, and beluga whales did so at received levels of 180 to 196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al., 1997; Schlundt et al., 2000). While animals were commonly reinforced with food during these studies, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Behavioral responses to a variety of sound sources have been studied in captive harbor porpoises, including acoustic alarms (Kastelein et al., 2006; Kastelein et al., 2001); emissions for underwater data transmission (Kastelein et al., 2005); and tones, including 1–2 kHz and 6–7 kHz sweeps with and without harmonics (Kastelein et al., 2014d), and 25 kHz with and without sidebands (Kastelein et al., 2015c; Kastelein et al., 2015d), and mid-frequency sonar tones at 3.5–4.1 kHz at 2.7 percent and 96 percent duty cycles (e.g., one tone per minute versus a continuous tone for almost a minute) (Kastelein et al., 2018). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the 1–2 kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the 6–7 kHz tonal at the same level (Kastelein et al., 2014d). When measuring the same sweeps for a startle response, the 50 percent response threshold was 133 and 101 dB re 1 μPa for 1–2 kHz and 6–7 kHz sweeps, respectively, when no harmonics were present, and decreased to 90 dB re 1 μPa for 1–2 kHz sweeps with harmonics present (Kastelein et al., 2014d). Harbor porpoises did not respond to the low-duty cycle mid-frequency tones at any received level, but one did respond to the high-duty cycle signal with more jumping and increased respiration rates (Kastelein et al., 2018). Harbor porpoises responded to seal scarers with 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 scarer with a fundamental (strongest) frequency of 18 kHz did not 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 in understanding species differences in the tolerance of 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 range 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 or even shorter as the animal assesses the sound and (based on prior experience or contextual cues) determines a threat is unlikely. Therefore, while odontocete behavioral responses to Navy sonar

will vary across species, populations, and individuals, they are not likely to lead to long-term consequences or population-level effects.

6.4.1.5.1.3 Pinnipeds

Richardson et al. (1995) noted that responsiveness to aircraft overflights generally was dependent on the altitude of the aircraft, the abruptness of the associated aircraft sound, and life cycle stage (breeding, molting, etc.). In general pinnipeds are unresponsive to overflights, and may startle, orient towards the sound source or increase vigilance, or may briefly re-enter the water, but typically remain hauled out or immediately return to their haul out location (Blackwell et al., 2004; Gjertz & Børset, 1992). Adult females, calves and juveniles are more likely to enter the water than males, and stampedes resulting in mortality to pups (by separation or crushing) can occur when disturbance is severe, although they are rare (Holst et al., 2011a). Responses may also be dependent on the distance of the aircraft. For example, reactions of walruses on land varied in severity and included minor head raising at a distance of 2.5 km, orienting toward or entering the water at less than 150 m and 1.3 km in altitude, to full flight reactions at horizontal ranges of less than 1 km at altitudes as high as 1,000–1,500 m (Richardson et al., 1995).

Helicopters are used in studies of several species of seals hauled out and are considered an effective means of observation (Bester et al., 2002; Gjertz & Børset, 1992), although they have been known to elicit behavioral reactions such as fleeing (Hoover, 1988). For California sea lions and Steller sea lions at a rocky haulout off Crescent City in northern California, helicopter approaches to landing sites typically caused the most severe response of diving into the water (National Oceanic and Atmospheric Administration, 2010). Responses were also dependent on the species, with Steller sea lions being more sensitive and California sea lions more tolerant. Depending on the time between subsequent approaches, animals hauled out in between and fewer animals reacted upon subsequent exposures (National Oceanic and Atmospheric Administration, 2010).

Pinniped reactions to rocket launches and overflight at San Nicolas Island were studied from August 2001 to October 2008 (Holst et al., 2011a). California sea lions startled and increased vigilance for up to two minutes after a rocket overflight, with some individuals moving down the beach or returning to the water. Northern elephant seals showed little reaction to any overflight. Harbor seals had the most pronounced reactions of the three species observed with most animals within approximately 4 km of the rocket trajectory leaving their haul-out sites for the water and not returning for several hours. The authors concluded that the effects of the rocket launches were minor with no effects on local populations evidenced by the growing populations of pinnipeds on San Nicolas Island (Holst et al., 2011b).

Pinnipeds may be more sensitive to unmanned aerial systems, especially those flying at low altitudes, due to their possible resemblance to predatorial birds (Smith et al., 2016), which could lead to flushing behavior (Olson, 2013). Responses may also vary by species, age class, behavior, and habituation to other anthropogenic noise, as well as by the type, size, and configuration of unmanned aerial vehicle used (Pomeroy et al., 2015). However, in general pinnipeds have demonstrated little to no response to unmanned aerial systems, with some orienting towards the vehicle, other alerting behavior, or short-term flushing possible (Moreland et al., 2015; Sweeney et al., 2015).

6.4.1.6 Stranding

Marine mammals are subjected to a variety of natural and anthropogenic factors, acting alone or in combination, which may cause a marine mammal to strand (Geraci et al., 1999; Geraci & Lounsbury, 2005). When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al., 1999; Geraci & Lounsbury, 2005; Perrin & 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 & Lounsbury, 2005). Specifically, under U.S. law, a stranding is an event in the wild in which: "(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 U.S.C. section 1421h).

Natural factors related to strandings include limited food availability or following prey inshore, predation, disease, parasitism, natural toxins, echolocation disturbance, climatic influences, and aging (Bradshaw et al., 2006; Culik, 2004; Geraci et al., 1999; Geraci & Lounsbury, 2005; Huggins et al., 2015; National Research Council, 2006; Perrin & Geraci, 2002; Walker et al., 2005). Anthropogenic factors include pollution (Hall et al., 2006; Jepson et al., 2005), vessel strike (Geraci & Lounsbury, 2005; Laist et al., 2001), fisheries interactions (Read et al., 2006), entanglement (Baird & Gorgone, 2005; Saez et al., 2013), human activities (e.g., feeding, gunshot) (Geraci & Lounsbury, 2005; Dierauf & Gulland, 2001), and noise (Cox et al., 2006; National Research Council, 2003; Richardson et al., 1995). For some stranding events, environmental factors (e.g., ocean temperature and wind speed and geographic conditions) can be utilized in predictive models to aid in understanding why marine mammals strand in certain areas more than others (Berini et al., 2015). In most instances, even for the more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for strandings remains undetermined.

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 12,545 cetacean strandings and 39,104 pinniped strandings (51,649 total) per year (National Marine Fisheries Service, 2016d). Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single mother-calf pair) that have occurred over the past two decades have been associated with anthropogenic activities that introduced sound into the marine environment, such as naval operations and seismic surveys. An in-depth discussion of strandings is in the Navy's technical report titled *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (U.S. Department of the Navy, 2017d).

Sonar use during exercises involving the U.S. Navy has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002; and Spain in 2006 (Cox et al., 2006; Fernandez, 2006; U.S. Department of the Navy, 2017d). These five mass strandings resulted in about 40 known cetacean deaths, consisting mostly of beaked whales and with close linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a potential indirect cause of death of the marine mammals (Cox et al., 2006). Strandings of other marine mammal species have not been as closely linked to sonar exposure, but rather have typically been attributed to

natural or anthropogenic factors. The Navy has reviewed training requirements, standard operating procedures, and possible mitigation measures and has implemented changes to reduce the potential for acoustic related strandings to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 11 (Mitigation Measures), which details all mitigation measures.

Multiple hypotheses regarding the relationship between non-impulsive sound exposure and stranding have been proposed (see Bernaldo de Quiros et al, 2019 Bernaldo de Quirós et al. (2019)). These range from direct impact of the sound on the physiology of the marine mammal, to behavioral reactions contributing to altered physiology (e.g., "gas and fat embolic syndrome" (Fernandez et al., 2005; Jepson et al., 2003; Jepson et al., 2005), 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 given 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.

Historically, stranding reporting and response efforts have been inconsistent, although they have improved considerably over the last 25 years. Although reporting forms have been standardized nationally, data collection methods, assessment methods, detail of reporting, and procedures vary by region and are not yet standardized across the United States. Conditions such as weather, time, location, and decomposition state may also affect the ability to thoroughly examine a specimen (Carretta et al., 2016b; Moore et al., 2013). Because of this, the current ability to interpret long-term trends in marine mammal stranding is limited. While the investigation of stranded animals provides insight into the types of threats marine mammal populations face, investigations are only conducted on a small fraction of the total number of strandings that occur, limiting our understanding of the causes of strandings (Carretta et al., 2016a).

Between May 2 and June 2, 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and one Dall's porpoise (*Phocoenoides dalli*) had been reported to the Northwest Marine Mammal Stranding Network. Given that the USS SHOUP was known to have operated sonar in the strait on May 5, and that behavioral reactions of killer whales (*Orcinus orca*) had been supposedly linked to these sonar operations (National Marine Fisheries Service, 2005), NMFS undertook an analysis of whether sonar caused the strandings of the harbor porpoises. It was subsequently determined that those 2003 strandings and similar harbor porpoise strandings over the following years were normal given a number of factors as described in Huggins et al. (2015). In the 2015 NWTT Final EIS/OEIS, a comprehensive review of all strandings and the events involving USS SHOUP on May 5, 2003, were discussed. Additional information on this event is available in the Navy's Technical Report on Marine Mammal Strandings Associated with U.S. Navy Sonar Activities (U.S. Department of the Navy, 2017d). It is important to note that in the years since the SHOUP incident, annual numbers of stranded porpoises not only increased but also showed similar causes of death (when determinable) to the causes of death noted in the SHOUP investigation (Huggins et al., 2015).

Stranded marine mammals are reported along the entire western coast of the United States each year. Marine mammals strand due to natural or anthropogenic causes; the majority of reported type of occurrences in marine mammal strandings in this region include fishery interactions, illness, predation, and vessel strikes (Carretta et al., 2017b; Helker et al., 2017; National Marine Fisheries Service, 2016f). It

is important to note that the mass stranding of pinnipeds along the U.S. West Coast considered part of a NMFS declared Unusual Mortality Event are still being evaluated. The likely cause of this event is the lack of available prey near rookeries due to warming ocean temperatures (National Marine Fisheries Service, 2016a). Carretta et al. (2013b; 2016b) provide additional information and data on the threats from human-related activities and the potential causes of strandings for the U.S. Pacific coast marine mammal stocks.

6.4.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate (see discussion in Section 6.2, Conceptual Framework for Assessing Effects from Sound-Producing Activities). 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. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual, or for very small populations to the population as a whole (e.g., Southern resident killer whale; however, short-term costs may be recouped during the life of an otherwise healthy individual). These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al., 2003). Highly resident or localized populations may also stay in an area of disturbance because the cost of displacement may be higher than the cost of remaining (Forney et al., 2017). Longer term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al., 2006b; Blackwell et al., 2004; Teilmann et al., 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al., 1984). Mysticetes in the northeast tended to adjust to vessel traffic over a number a of years, trending towards more neutral responses to passing vessels (Watkins, 1986), indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. West Coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound including the use of sonar by the U.S. Navy; however, new data have been published, raising uncertainties over whether a decline in the beaked whale population occurred off the U.S. West Coast between 1996 and 2014 (Barlow, 2016). Moore and Barlow (2017) have since incorporated information from the entire 1991 to

2014 time series, which suggests an increasing abundance trend and a reversal of the declining trend along the U.S. West Coast that had been noted in their previous (2013) analysis.

In addition, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blainville's beaked whales may be resident during all or part of the year in the area. Individuals may move off the range for several days during and following a sonar event, but return within a few days (McCarthy et al., 2011; Tyack et al., 2011). Photo-identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to seven years apart (Falcone et al., 2009; Falcone & Schorr, 2014). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact on population growth rates, and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard, however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of which was associated with her second calf; and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et al., 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the Southern California Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of kilometers by some of those animals. Schorr et al. (2014) reported the results for an additional eight tagged Cuvier's beaked whales in the same area. Five of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km south to Mexico and back again. Given that some beaked whales may routinely move hundreds of kilometers as part of their normal pattern (Schorr et al., 2014), temporarily leaving an area to avoid sonar or other anthropogenic activity may have little cost.

Another approach to investigating long-term consequences of anthropogenic noise exposure has been an attempt to link short-term effects to individuals from anthropogenic stressors with long-term consequences to populations using population models. Population models are well known from many fields in biology, including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population, such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, that can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and ultimately population-level effects. The linkage between immediate behavioral or physiological effects to an individual due to a stressor such as sound, the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and in turn the consequences for the population, have been reviewed in National Research Council (2005).

The Population Consequences of Acoustic Disturbance (PCAD) model (National Research Council 2005) proposes a conceptual model for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the PCAD 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 & King, 2014; Hatch et al., 2012; King et al., 2015; New et al., 2013a; New et al., 2013b; New et al., 2014). Currently, the Population Consequences of Disturbance model provides a theoretical framework and identifies types of data that would be needed to assess population-level impacts using this process. The process is complicated and provides a foundation for the type of data that is needed, which is currently lacking for many marine mammal species. Relevant data needed for improving these analytical approaches for population-level consequences resulting from disturbances will continue to be collected during projects funded by the Navy's marine species monitoring program.

Costa et al. (2016a) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory, or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. For example, Costa (2016a) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent (respectively) of each population would be exposed, and less than 19 percent and 6 percent (respectively) of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, but 100 percent of their foraging time would occur during an exposure when the zone was over 25 km or more. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Similarly, Costa et al. (2016b) placed disturbance zones in the foraging and transit areas of northern elephant seals and California sea lions. Again, the location and radius of disturbance impacted how many animals were exposed and for how long, with California sea lions disturbed for a longer period than elephant seals, which extend over a broader foraging and transit area. However, even the animals exposed for the longest periods had negligible modeled impacts on their reproduction and pup survival rates. Energetic costs were estimated for western gray whales that migrated to possible wintering grounds near China or to the Baja California wintering grounds of eastern gray whales versus the energetic costs of the shorter migration of eastern gray whales (Villegas-Amtmann et al., 2017). Researchers found that when the time spent on the breeding grounds was held constant for both populations, the energetic requirements for the western gray whales were estimated to be 11 and 15 percent greater during the migration to Baja California and China, respectively, than for the migration of eastern gray whales, and therefore this population would be more sensitive to energy lost through disturbance (Costa et al., 2016b).

Pirotta et al. (2018) modeled one reproductive cycle of a female North Pacific blue whale, starting with leaving the breeding grounds off Baja California to begin migrating north to feeding grounds off

California, and ending with her returning to the breeding grounds, giving birth, and lactating. They modeled this scenario with no disturbance and found 95 percent calf recruitment. Under a "normal" environmental perturbation (El Niño-Southern Oscillation), there was a very small reduction in recruitment, and under an "unprecedented" environmental change, recruitment was reduced to 69 percent. An intense, localized anthropogenic disturbance was modeled (although the duration of the event was not provided); if the animals were not allowed to leave the area, they did not forage and recruitment dropped to 63 percent. However, if animals could leave the area of the disturbance then there was almost no change to the recruitment rate. Finally, a weak but broader spatial disturbance, where foraging was reduced by 50 percent, caused only a small decrease in calf recruitment to 94 percent.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the extreme and unlikely assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts on the population size and no long-term effects on population viability. Similarly, King et al. (2015) developed a Population Consequences of Disturbance framework using expert elicitation data on impacts from wind farms on harbor porpoises, and even under the worst-case scenarios predicted less than a 0.5 percent decline in harbor porpoise populations. Nabe-Nelson et al. (2014) also modeled the impact of noise from wind farms on harbor porpoises and predicted that even when assuming a 10 percent reduction in population size if prey is impacted up to 2 days, the presence of ships and wind turbines did not deplete the population. In contrast, Heinis and De Jong (2015) used the Population Consequences of Disturbance framework to estimate impacts from both pile driving and seismic exploration on harbor porpoises and found a 23 percent decrease in population size over 6 years, with an increased risk for further reduction with additional disturbance days. These seemingly contradictory results demonstrate that refinements to models need to be investigated to improve consistency and interpretation of model results.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy-dense prey and high-quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival; however, the authors were forced to use many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more, indicating that temporary displacement from a small area may not preclude finding energy dense prey or high quality habitat. 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.

Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips (only a 0.4 percent population decline in the following year). McHuron et al. (2018) modeled the introduction of a generalized disturbance at different times throughout the breeding cycle

of California sea lions, with the behavioral response being an increase in the duration of a foraging trip by the female. Very short duration disturbances or responses led to little change, particularly if the disturbance was a single event, and changes in the timing of the event in the year had little effect. However, with even relatively short disturbances or mild responses, when a disturbance was modeled as recurring there were resulting reductions in population size and pup recruitment. Often, the effects weren't noticeable for several years, as the impacts on pup recruitment did not affect the population until those pups were mature.

It should be noted that, in all of these models, assumptions were made and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population-level effects.

The best assessment of long-term consequences from Navy training and testing activities will be to monitor the populations over time within the Study Area. A U.S. workshop on Marine Mammals and Sound (Fitch et al., 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed and implemented comprehensive monitoring plans since 2009 for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's mitigation measures. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (Martin et al., 2017); preliminary results of this analysis at the Pacific Missile Range Facility off Kauai, Hawaii, indicate no changes in detection rates for several species over the past decade, demonstrating that Navy activities may not be having long-term population-level impacts. This type of analysis can be expanded to the other Navy ranges, such as in the Pacific Northwest. Continued analysis of this 15-year dataset and additional monitoring efforts over time are necessary to fully understand the long-term consequences of exposure to military readiness activities.

6.4.2 Impacts from Sonar and Other Transducers

Sonar and other transducers proposed for use could be used throughout the Study Area. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 1.4.1 (Acoustic Stressors).

Sonar-induced acoustic resonance and bubble formation phenomena are very unlikely to occur under realistic conditions, as discussed in Section 6.4.1.1 (Injury). Non-auditory injury (i.e., other than PTS) and mortality from sonar and other transducers is so unlikely as to be discountable under normal conditions and is therefore not considered further in this analysis.

The most probable impacts from exposure to sonar and other transducers are PTS, TTS, behavioral reactions, masking, and physiological stress (Sections 6.4.1.2, Hearing Loss; 6.4.1.3, Physiological Stress; and 6.4.1.5, Behavioral Reactions).

6.4.2.1 Methods for Analyzing Impacts from Sonars and Other Transducers

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be affected by sonars and other transducers used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts on marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times that animals may experience these effects;

these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures.

The steps of this quantitative analysis are described in the NWTT Draft Supplemental EIS/OEIS, Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals), which takes into account the following:

- Criteria and thresholds used to predict impacts from sonar and other transducers (see below)
- The density and spatial distribution of marine mammals
- The influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation when estimating the received sound level on the animals

A detailed explanation of this analysis is provided in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

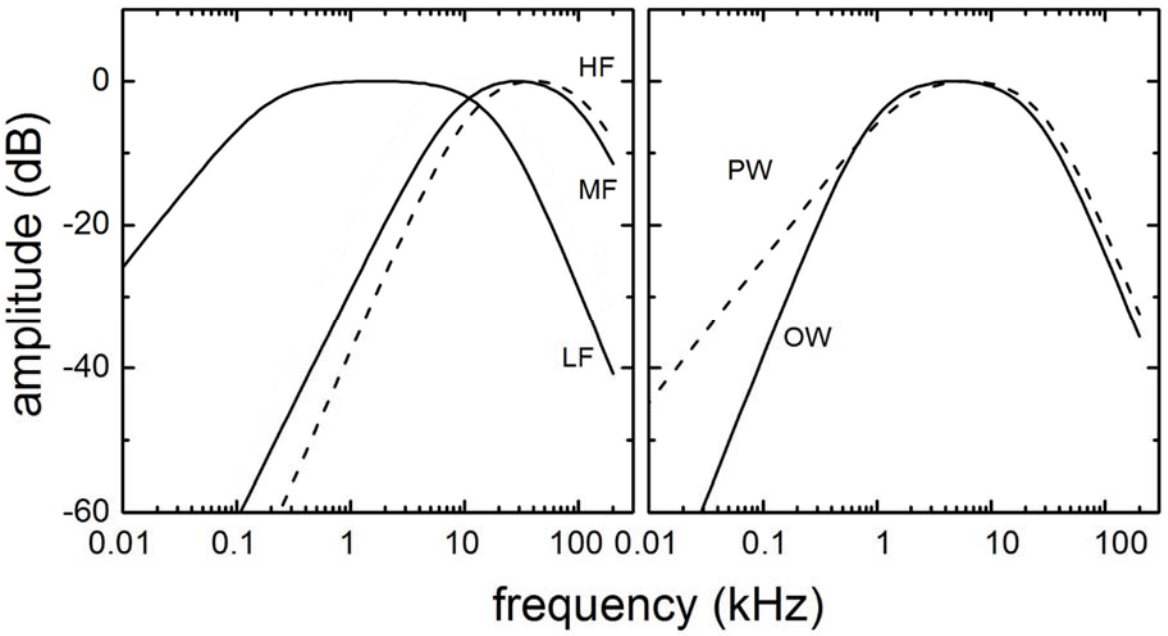
6.4.2.1.1 Criteria and Thresholds Used to Estimate Impacts from Sonar and Other Transducers

Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used (Figure 6-6). 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 are based on a generic band pass filter and incorporate species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL. Due to the band pass nature of auditory weighting functions, they resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.

Hearing Loss from Sonar and Other Transducers

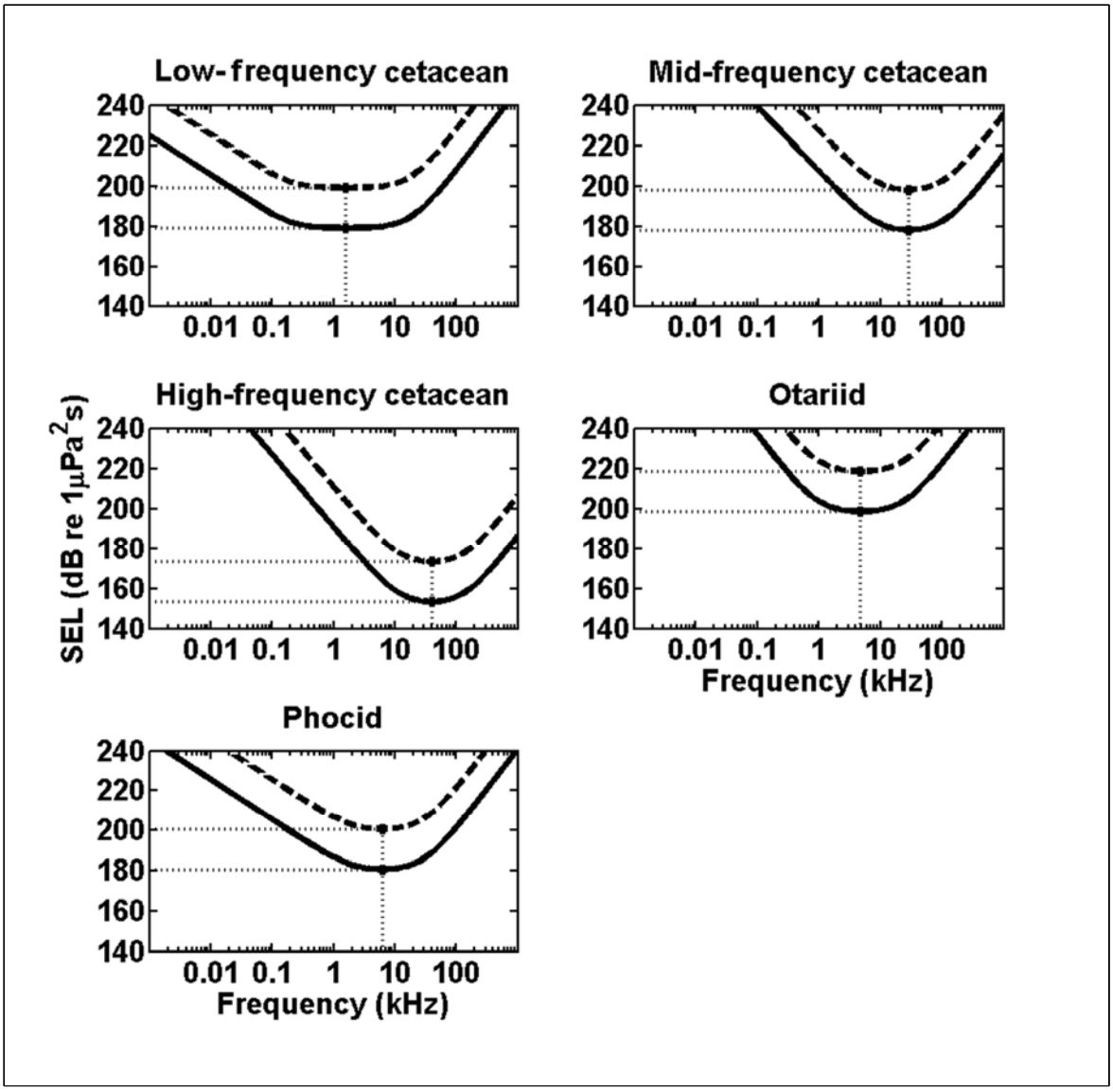
Defining the TTS and PTS exposure functions (see Figure 6-7) requires identifying the weighted exposures necessary for TTS and PTS onset from sounds produced by sonar and other transducers. The criteria used to define threshold shifts from non-impulsive sources (e.g., sonar) determines TTS onset as the SEL necessary to induce 6 dB of threshold shift. A sound exposure level 20 dB above the onset of TTS is used in all hearing groups of marine mammals underwater to define the PTS threshold (Southall et al., 2007).



Source: For parameters used to generate the functions and more information on weighting function derivation, see the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report U.S. Department of the Navy (2017b)

Notes: HF = high-frequency cetacean, LF = low-frequency cetacean, MF = mid-frequency cetacean, PW = phocid (in-water), and OW = otariid (in-water).

Figure 6-6: Navy Auditory Weighting Functions for All Species Groups



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

Figure 6-7: TTS and PTS Exposure Functions for Sonar and Other Transducers

Behavioral Responses from Sonar and Other Transducers

Behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response to sonar and other transducers. See the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2017b) for detailed information on how the Behavioral Response Functions were derived. Developing the new behavioral criteria involved multiple steps. All peer-reviewed published 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.

The data from the behavioral studies were analyzed by looking for significant responses, or lack thereof, for each experimental session. The terms "significant response" or "significant behavioral response" are used in describing behavioral observations from field or captive animal research that may rise to the level of "harassment" for military readiness activities. Under the MMPA, for military readiness activities, such as Navy training and testing, behavioral "harassment" is: "any act that *disturbs* or is likely to *disturb* a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering*, to a point where such behavioral patterns are abandoned or significantly altered*" (16 U.S.C. section 1362(3)(18)(B)).

The likelihood of injury due to disruption of normal behaviors would depend on many factors, such as the duration of the response, what the animal is being diverted from, and life history of the animal. 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, the Navy has developed a methodology to estimate the possible significance of behavioral reactions and impacts on natural behavior patterns.

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

Moderate severity responses included

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

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have

continued if the exposure had continued. The costs associated with these observed behavioral reactions were not measured, so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case. High-severity responses include those responses with immediate consequences (e.g., stranding, mother-calf separation), and were always considered significant behavioral reactions regardless of duration.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 6-8 through Figure 6-11). In most cases, these divisions are driven by taxonomic classifications (e.g., mysticetes, odontocetes). The Odontocete group combines most of the mid- and high-frequency cetaceans, without the beaked whales. These groups are combined as there are not enough data to separate them for behavioral responses.

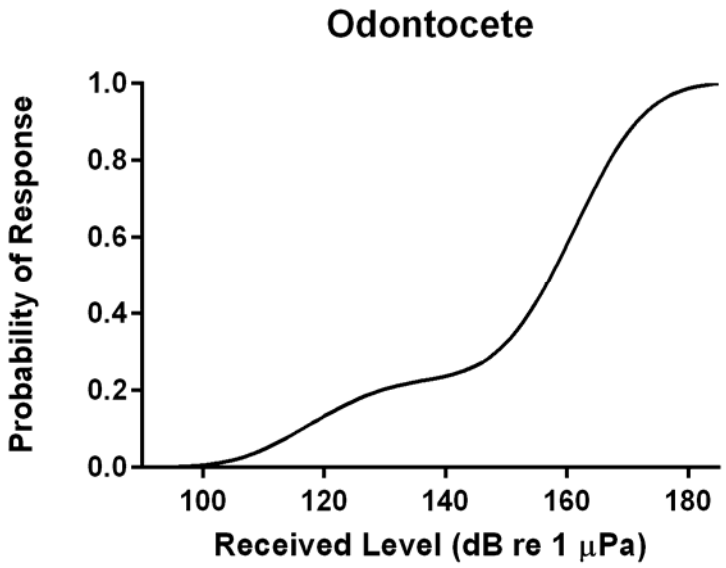


Figure 6-8: Behavioral Response Function for Odontocetes

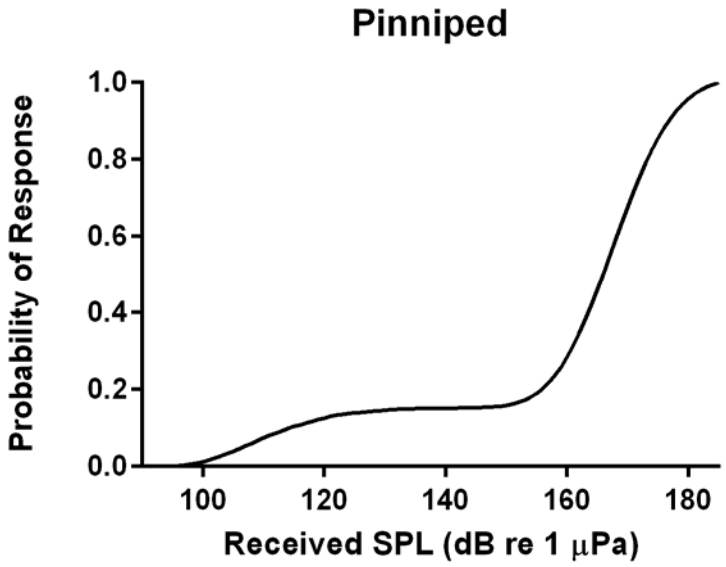


Figure 6-9: Behavioral Response Function for Pinnipeds

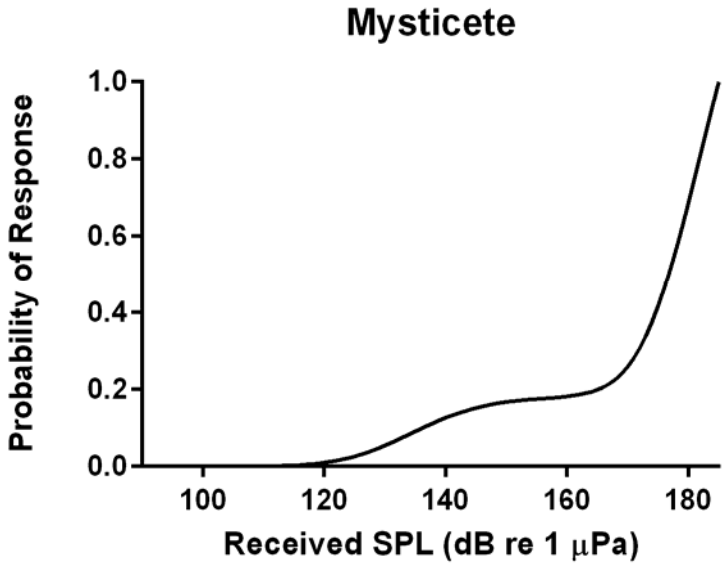


Figure 6-10: Behavioral Response Function for Mysticetes

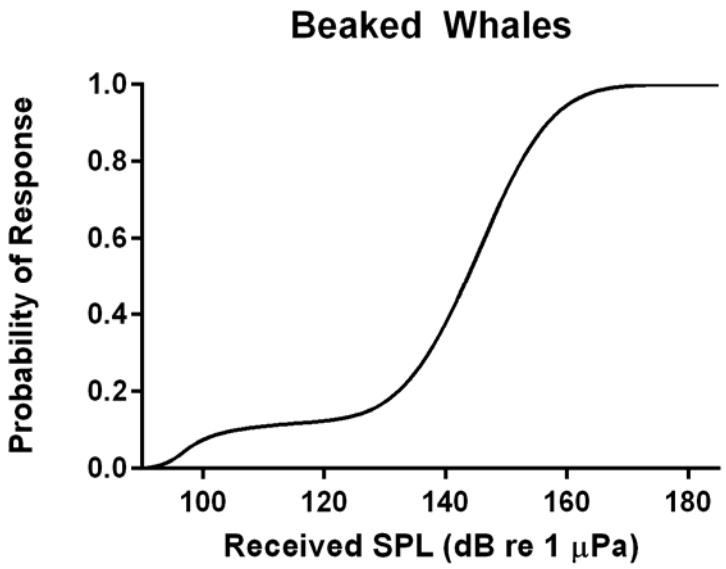


Figure 6-11: Behavioral Response Function for Beaked Whales

The information currently available regarding harbor porpoises suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (Kastelein et al., 2000; Kastelein et al., 2005) and wild harbor porpoises (Johnston, 2002) responded to sound (e.g., acoustic harassment devices, acoustic deterrent devices, or other non-impulsive sound sources) are very low, approximately 120 dB re 1 µPa. Therefore, an SPL of 120 dB re 1 µPa is used in this analysis as a threshold for predicting behavioral responses in harbor porpoises.

For all taxa, distances beyond which significant behavioral responses to sonar and other transducers are unlikely to occur, denoted as "cutoff distances," were defined based on existing data (Table 6-2). The distance between the animal and the sound source is a strong factor in determining that animal's potential reaction (e.g., DeRuiter et al., 2013b). For training and testing activities 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 probably increase responsiveness in marine mammals overall. There are currently few behavioral observations under these circumstances; therefore, the Navy will conservatively predict significant behavioral responses at further ranges for these more intense activities.

Table 6-2: Cutoff Distances for Moderate Source Level, Single Platform Training and Testing Events and for All Other Events with Multiple Platforms or Sonar with Source Levels at or Exceeding 215 dB re 1 µPa @ 1 m

Criteria Group	*Moderate SL/Single Platform Cutoff Distance*	*High SL/Multi-Platform Cutoff Distance*
Odontocetes	10 km	20 km
Pinnipeds	5 km	10 km
Mysticetes	10 km	20 km
Beaked Whales	25 km	50 km
Harbor Porpoise	20 km	40 km

Notes: dB re 1 µPa @ 1 m = decibels referenced to 1 micropascal at 1 meter, km = kilometer, SL = source level

6.4.2.1.2 Assessing the Severity of Behavioral Responses from Sonar

As discussed above, the terms "significant response" or "significant behavioral response" are used in describing behavioral reactions that may lead to an abandonment or significant alteration of a natural behavior pattern. Due to the limited amount of behavioral response research to date and relatively short durations of observation, it is not possible to ascertain the true significance of the majority of the observed reactions. When deriving the behavioral criteria, it was assumed that most reactions that lasted for the duration of the sound exposure or longer were significant, even though many of the exposures lasted for 30 minutes or less. Furthermore, the experimental designs used during many of the behavioral response studies were unlike Navy activities in many important ways. These differences include tagging subject animals, following subjects for sometimes hours before the exposure, vectoring towards the subjects after animals began to avoid the sound source, and making multiple close passes on focal groups. This makes the estimated behavioral impacts from Navy activities using the criteria derived from these experiments difficult to interpret. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b), Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

The estimated behavioral reactions from the Navy's quantitative analysis are grouped into several categories based on the most powerful sonar source, the number of platforms, the duration, and geographic extent of each Navy activity attributed to the predicted impact. Activities that occur on Navy-instrumented ranges or within Navy homeports require special consideration due to the repeated nature of activities in these areas.

Low-severity responses are within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Although the derivation of the Navy's behavioral criteria did not count low-severity responses as significant behavioral responses, in practice, some reactions estimated using the behavioral criteria are likely to be low severity (Figure 6-12).

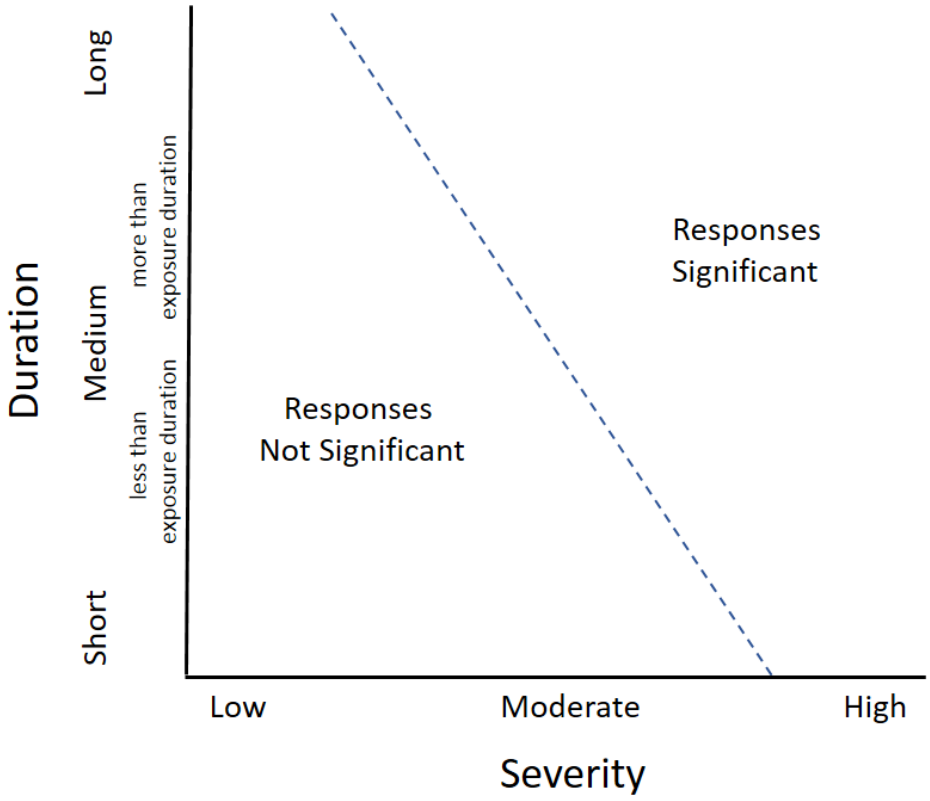


Figure 6-12: Relative Likelihood of a Response Being Significant Based on the Duration and Severity of Behavioral Reactions

High-severity responses are those with a higher potential for direct consequences to growth, survivability, or reproduction. Examples include prolonged separation of females and dependent offspring, panic, flight, stampede, or stranding. High-severity reactions would always be considered significant; however, these types of reactions are probably rare under most conditions and may still not lead to direct consequences on survivability. For example, a separation of a killer whale mother-calf pair was observed once during a behavioral response study to an active sonar source (Miller et al., 2014), but the animals were rejoined as soon as the ship had passed. Therefore, although this was a severe response, it did not lead to a negative outcome. Five beaked whale strandings have also occurred associated with U.S. Navy active sonar use as discussed above (Section 6.4.1.6, Stranding), but the confluence of factors that contributed to those strandings is now better understood, and the avoidance of those factors has resulted in no known marine mammal strandings associated with U.S. Navy sonar activities for over a decade. The Navy is unable to predict these high-severity responses for any activities since the probability of occurrence is apparently very low, although the Navy acknowledges that severe reactions could occasionally occur. In fact, no significant behavioral responses such as panic, stranding, or other severe reactions have been observed during monitoring of actual training or testing activities.

Many of the responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate-severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As mentioned previously, the behavioral response functions used within the Navy's quantitative analysis were primarily derived from

experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate-severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sonar that may exceed an animal's behavioral threshold for only a single ping to several minutes. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b), the Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

6.4.2.1.2.1 Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from active sonar on marine mammals (described in Chapter 11, Mitigation Measures). The benefits of mitigation are conservatively factored into the analysis of the proposed training and testing.

Procedural mitigation measures include a power down or shut down (i.e., power off) of applicable active sonar sources when a marine mammal is observed in a mitigation zone. The mitigation zones for active sonar activities were designed to avoid the potential for marine mammals to be exposed to levels of sound that could result in auditory injury (i.e., PTS) from active sonar to the maximum extent practicable. The mitigation zones for active sonar extend beyond the respective average ranges to auditory injury (including PTS). Therefore, the impact analysis quantifies the potential for procedural mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of procedural mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

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

The ability to observe the range to PTS was estimated for each training or testing event. The ability of Navy Lookouts to detect marine mammals within a 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. Certain behaviors, such as leaping and breaching, are visible from a great distance and likely increase sighting distances and detections of those species. Environmental conditions under which the training or testing activity could take place are also considered, such as sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain active sonar activities within mitigation areas, as described in Appendix K (Geographic Mitigation Assessment) of the 2019 NWTT Draft Supplemental EIS/OEIS. The benefits of mitigation areas are discussed qualitatively and have not been factored into the quantitative analysis process or reductions in take for impact estimates. Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. Therefore, mitigation area benefits are discussed in terms of the context of impact avoidance or reduction.

6.4.2.1.2.2 Marine Mammal Avoidance of Sonar and other Transducers

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

6.4.2.2 Impact Ranges for Sonar and Other Transducers

The following section provides range to effects for sonar and other transducers to specific criteria determined using the Navy Acoustic Effects Model. Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting acoustic impacts, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that will likely be mitigated within applicable mitigation zones.

The ranges to the PTS threshold for an exposure of 30 seconds are shown in Table 6-3 relative to the marine mammal's functional hearing group. This period (30 seconds) was chosen based on examining the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 meters 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. Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10 and 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other bins (besides MF1), PTS ranges are short enough that marine mammals (with a nominal swim speed of approximately 1.5 meters per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

For all other functional hearing groups (low-frequency cetaceans, mid-frequency cetaceans, phocid, seals, and otariids), 30-second average PTS zones are substantially shorter. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship, however, the close distances required make PTS exposure unlikely. For a military vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to suffer PTS.

The tables below illustrate the range to TTS for 1, 30, 60, and 120 seconds from five representative sonar systems (see Table 6-4 through Table 6-8). 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 6-3: Range to Permanent Threshold Shift for Five Representative Sonar Systems

Hearing Group	*Approximate PTS (30 seconds) Ranges (meters)*[1]				
	Sonar bin HF4	*Sonar bin LF4*	*Sonar bin MF1*	*Sonar bin MF4*	*Sonar bin MF5*
High-frequency cetaceans	38 (22–85)	0 (0–0)	195 (80–330)	30 (30–40)	9 (8–11)
Low-frequency cetaceans	0 (0–0)	2 (1–3)	67 (60–110)	15 (15–17)	0 (0–0)
Mid-frequency cetaceans	1 (0–3)	0 (0–0)	16 (16–19)	3 (3–3)	0 (0–0)
Otariids	0 (0–0)	0 (0–0)	6 (6–6)	0 (0–0)	0 (0–0)
Phocids	0 (0–0)	0 (0–0)	46 (45–75)	11 (11–12)	0 (0–0)

[1] PTS ranges extend from the sonar or other transducer sound source to the indicated distance. The average range to PTS is provided as well as the range from the estimated minimum to the maximum range to PTS in parenthesis.
Notes: HF = high-frequency, LF = low-frequency, MF = mid-frequency, PTS = permanent threshold shift

Table 6-4: Ranges to Temporary Threshold Shift for Sonar Bin HF4 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin HF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	236 (60–675)	387 (60–875)	503 (60–1,025)	637 (60–1,275)
Low-frequency cetaceans	2 (0–3)	3 (1–6)	5 (3–8)	8 (5–12)
Mid-frequency cetaceans	12 (7–20)	21 (12–40)	29 (17–60)	43 (24–90)
Otariids	0 (0–0)	0 (0–0)	0 (0–0)	1 (0–1)
Phocids	3 (0–5)	6 (4–10)	9 (5–15)	14 (8–25)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Notes: HF = high-frequency, TTS = temporary threshold shift

Table 6-5: Ranges to Temporary Threshold Shift for Sonar Bin LF4 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin LF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	1 (0–1)
Low-frequency cetaceans	22 (19–30)	32 (25–230)	41 (30–230)	61 (45–100)
Mid-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Otariids	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Phocids	2 (1–3)	4 (3–4)	4 (4–5)	7 (6–9)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Notes: HF = high-frequency, TTS = temporary threshold shift

Table 6-6: Ranges to Temporary Threshold Shift for Sonar Bin MF1 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin MF1			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	2,466 (80–6,275)	2,466 (80–6,275)	3,140 (80–10,275)	3,740 (80–13,525)
Low-frequency cetaceans	1,054 (80–2,775)	1,054 (80–2,775)	1,480 (80–4,525)	1,888 (80–5,275)
Mid-frequency cetaceans	225 (80–380)	225 (80–380)	331 (80–525)	411 (80–700)
Otariids	67 (60–110)	67 (60–110)	111 (80–170)	143 (80–250)
Phocids	768 (80–2,025)	768 (80–2,025)	1,145 (80–3,275)	1,388 (80–3,775)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis. Ranges for 1 second and 30 second periods are identical for Bin MF1 because this system nominally pings every 50 seconds; therefore, these periods encompass only a single ping.

Notes: MF = mid-frequency, TTS = temporary threshold shift

Table 6-7: Ranges to Temporary Threshold Shift for Sonar Bin MF4 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin MF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	279 (220–600)	647 (420–1,275)	878 (500–1,525)	1,205 (525–2,275)
Low-frequency cetaceans	87 (85–110)	176 (130–320)	265 (190–575)	477 (290–975)
Mid-frequency cetaceans	22 (22–25)	35 (35–45)	50 (45–55)	71 (70–85)
Otariids	8 (8–8)	15 (15–17)	19 (19–23)	25 (25–30)
Phocids	66 (65–80)	116 (110–200)	173 (150–300)	303 (240–675)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.

Notes: MF = mid-frequency, TTS = temporary threshold shift

Table 6-8: Ranges to Temporary Threshold Shift for Sonar Bin MF5 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin MF5			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	115 (110–180)	115 (110–180)	174 (150–390)	292 (210–825)
Low-frequency cetaceans	11 (10–13)	11 (10–13)	17 (16–19)	24 (23–25)
Mid-frequency cetaceans	6 (0–9)	6 (0–9)	12 (11–14)	18 (17–22)
Otariids	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Phocids	9 (8–11)	9 (8–11)	15 (14–17)	22 (21–25)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Notes: MF = mid-frequency, TTS = temporary threshold shift

The range to received sound levels in 6 dB steps from five representative sonar bins and the percentage of animals that may exhibit a significant behavioral response under each behavioral response function (or step function in the case of the harbor porpoise) are shown in Table 6-9 through Table 6-13. See Section 6.4.2.1 (Methods for Analyzing Impacts from Sonars and Other Transducers) for details on the derivation and use of the behavioral response functions, thresholds, and the cutoff distances.

Table 6-9: Ranges to a Potentially Significant Behavioral Response for Sonar Bin HF4 over a Representative Range of Environments within the Study Area

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*	*Pinniped*	*Beaked Whale*	*Harbor Porpoise*
196	4 (0–7)	100%	100%	100%	100%	100%
190	10 (0–16)	100%	98%	99%	100%	100%
184	20 (0–40)	99%	88%	98%	100%	100%
178	42 (0–85)	97%	59%	92%	100%	100%
172	87 (0–270)	91%	30%	76%	99%	100%
166	177 (0–650)	78%	20%	48%	97%	100%
160	338 (25–825)	58%	18%	27%	93%	100%
154	577 (55–1,275)	40%	17%	18%	83%	100%
148	846 (60–1,775)	29%	16%	16%	66%	100%
142	1,177 (60–2,275)	25%	13%	15%	45%	100%
136	1,508 (60–3,025)	23%	9%	15%	28%	100%
130	1,860 (60–3,525)	20%	5%	15%	18%	100%
124	2,202 (60–4,275)	17%	2%	14%	14%	100%
118	2,536 (60–4,775)	12%	1%	13%	12%	0%
112	2,850 (60–5,275)	6%	0%	9%	11%	0%
106	3,166 (60–6,025)	3%	0%	5%	11%	0%
100	3,470 (60–6,775)	1%	0%	2%	8%	0%

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, HF = high-frequency

Table 6-10: Ranges to a Potentially Significant Behavioral Response for Sonar Bin LF4 over a Representative Range of Environments Within the Study Area

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*	*Pinniped*	*Beaked Whale*	*Harbor Porpoise*
196	1 (0–1)	100%	100%	100%	100%	100%
190	3 (0–3)	100%	98%	99%	100%	100%
184	6 (0–8)	99%	88%	98%	100%	100%
178	13 (0–30)	97%	59%	92%	100%	100%
172	29 (0–230)	91%	30%	76%	99%	100%
166	64 (0–100)	78%	20%	48%	97%	100%
160	148 (0–310)	58%	18%	27%	93%	100%
154	366 (230–850)	40%	17%	18%	83%	100%
148	854 (300–2,025)	29%	16%	16%	66%	100%
142	1,774 (300–5,025)	25%	13%	15%	45%	100%
136	3,168 (300–8,525)	23%	9%	15%	28%	100%
130	5,167 (300–30,525)	20%	5%	15%	18%	100%
124	7,554 (300–93,775)	17%	2%	14%	14%	100%
118	10,033 (300–100,000*)	12%	1%	13%	12%	0%
112	12,700 (300–100,000*)	6%	0%	9%	11%	0%
106	15,697 (300–100,000*)	3%	0%	5%	11%	0%
100	17,846 (300–100,000*)	1%	0%	2%	8%	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 (see Table 6-2 for behavioral cut-off distances). dB re 1 µPa = decibels referenced to 1 micropascal, LF = low-frequency

Table 6-11: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF1 over a Representative Range of Environments within the Study Area

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*	*Pinniped*	*Beaked Whale*	*Harbor Porpoise*
196	112 (80–170)	100%	100%	100%	100%	100%
190	262 (80–410)	100%	98%	99%	100%	100%
184	547 (80–1,025)	99%	88%	98%	100%	100%
178	1,210 (80–3,775)	97%	59%	92%	100%	100%
172	2,508 (80–7,525)	91%	30%	76%	99%	100%
166	4,164 (80–16,025)	78%	20%	48%	97%	100%
160	6,583 (80–28,775)	58%	18%	27%	93%	100%
154	10,410 (80–47,025)	40%	17%	18%	83%	100%
148	16,507 (80–63,525)	29%	16%	16%	66%	100%
142	21,111 (80–94,025)	25%	13%	15%	45%	100%
136	26,182 (80–100,000*)	23%	9%	15%	28%	100%
130	31,842 (80–100,000*)	20%	5%	15%	18%	100%
124	34,195 (80–100,000*)	17%	2%	14%	14%	100%
118	36,557 (80–100,000*)	12%	1%	13%	12%	0%
112	38,166 (80–100,000*)	6%	0%	9%	11%	0%
106	39,571 (80–100,000*)	3%	0%	5%	11%	0%
100	41,303 (80–100,000*)	1%	0%	2%	8%	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 (see Table 6-2 for behavioral cut-off distances). dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 6-12: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF4 over a Representative Range of Environments within the Study Area

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*	*Pinniped*	*Beaked Whale*	*Harbor Porpoise*
196	8 (0–8)	100%	100%	100%	100%	100%
190	16 (0–20)	100%	98%	99%	100%	100%
184	34 (0–40)	99%	88%	98%	100%	100%
178	68 (0–85)	97%	59%	92%	100%	100%
172	155 (120–300)	91%	30%	76%	99%	100%
166	501 (290–975)	78%	20%	48%	97%	100%
160	1,061 (480–2,275)	58%	18%	27%	93%	100%
154	1,882 (525–4,025)	40%	17%	18%	83%	100%
148	2,885 (525–7,525)	29%	16%	16%	66%	100%
142	4,425 (525–14,275)	25%	13%	15%	45%	100%
136	9,902 (525–48,275)	23%	9%	15%	28%	100%
130	20,234 (525–56,025)	20%	5%	15%	18%	100%
124	23,684 (525–91,775)	17%	2%	14%	14%	100%
118	28,727 (525–100,000*)	12%	1%	13%	12%	0%
112	37,817 (525–100,000*)	6%	0%	9%	11%	0%
106	42,513 (525–100,000*)	3%	0%	5%	11%	0%
100	43,367 (525–100,000*)	1%	0%	2%	8%	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 (see Table 6-2 for behavioral cut-off distances). dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 6-13: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF5 over a Representative Range of Environments within the Study Area

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*	*Pinniped*	*Beaked Whale*	*Harbor Porpoise*
196	0 (0–0)	100%	100%	100%	100%	100%
190	1 (0–3)	100%	98%	99%	100%	100%
184	5 (0–7)	99%	88%	98%	100%	100%
178	14 (0–18)	97%	59%	92%	100%	100%
172	29 (0–35)	91%	30%	76%	99%	100%
166	58 (0–70)	78%	20%	48%	97%	100%
160	127 (0–280)	58%	18%	27%	93%	100%
154	375 (0–1,000)	40%	17%	18%	83%	100%
148	799 (490–1,775)	29%	16%	16%	66%	100%
142	1,677 (600–3,525)	25%	13%	15%	45%	100%
136	2,877 (675–7,275)	23%	9%	15%	28%	100%
130	4,512 (700–12,775)	20%	5%	15%	18%	100%
124	6,133 (700–19,275)	17%	2%	14%	14%	100%
118	7,880 (700–26,275)	12%	1%	13%	12%	0%
112	9,673 (700–33,525)	6%	0%	9%	11%	0%
106	12,095 (700–45,275)	3%	0%	5%	11%	0%
100	18,664 (700–48,775)	1%	0%	2%	8%	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 (see Table 6-2 for behavioral cut-off distances). dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

6.4.2.3 Impacts from Sonar and Other Transducer Stressors Under the Proposed Action

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training are described in Section 1.4.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Section 1.5.1 (Training and Testing Activities).

Anti-submarine warfare activities include unit-level training and testing activities, and anti-submarine warfare sonar systems would be active when conducting surface ship and submarine sonar maintenance. Submarine and surface ship sonar maintenance activities involve the use of a single system in a limited manner; therefore, significant reactions to maintenance are less likely than with most other anti-submarine warfare activities. Furthermore, sonar maintenance activities typically occur either pierside or within entrances to harbors where higher levels of anthropogenic activity, including elevated noise levels, already exist. Unit-level training activities typically involve the use of a single vessel or aircraft and last for only a few hours over a small area of ocean. These unit-level training and

sonar maintenance activities are limited in scope and duration; therefore, significant behavioral reactions are less likely to occur. Unit-level training activities are more likely to occur close to homeports and in the same general locations each time, so resident animals could be more frequently exposed to these types of activities.

Anti-submarine warfare testing activities are typically similar to unit-level training. Vessel evaluation testing activities also use the same anti-submarine warfare sonars on ships and submarines. Testing activities that use anti-submarine warfare sonars typically occur in water deeper than approximately 200 m and therefore out of most nearshore habitats where productivity is typically higher (i.e., more food) and many marine mammals have higher abundances. Therefore, significant reactions to anti-submarine warfare and vessel evaluation testing activities are less likely than with larger anti-submarine warfare training activities discussed above in Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities. Anti-submarine warfare and vessel evaluation testing activities are more likely to occur close to homeports and testing facilities and in the same general locations each time, so resident animals could be more frequently exposed to these types of activities. These testing activities are limited in scope and duration; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Mine warfare training activities typically involve a ship, helicopter, or unmanned vehicle using a mine-hunting sonar to locate mines. Most mine warfare sonar systems have a lower source level, higher-frequency, and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to mine warfare sonars. While individual animals could show short-term and minor responses to mine warfare sonar training activities, these reactions are very unlikely to lead to any costs or long-term consequences for individuals or populations.

Mine warfare testing activities typically involve a ship, helicopter, or unmanned vehicle testing a mine-hunting sonar system. Unmanned underwater vehicle testing also employs many of the same sonar systems as mine warfare testing and usually involves only a single sonar platform (i.e., unmanned underwater vehicle). Most of the sonar systems and other transducers used during these testing activities typically have a lower source level, higher-frequency, and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to these types of systems sonars. Animals are most likely to show short-term and minor to moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Acoustic and Oceanographic Science and Research uses a number of different sonar systems and other transducers to sense and measure the parameters of the ocean (e.g., temperature) and conduct research on the ways sound travels underwater. Many of these systems generate only moderate sound levels and are stationary. Significant reactions in marine mammals have not been reported due to exposure to the sonars and other transducers typically used in these activities. Animals are most likely to show short-term and minor to moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Other testing activities include testing of individual sonar systems and other transducers for performance and acoustic signature. Most sources used during these exercises have moderate source

levels between 160 and 200 dB re 1 µPa @ 1m and are used for a limited duration, up to a few hours in most cases. Significant reactions in marine mammals have not been reported due to exposure to the sonars and other transducers typically used in these activities. Animals are most likely to show short-term and minor to moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

6.4.2.3.1 Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from sonars and other transducers (Section 6.4.2.1, Methods for Analyzing Impacts from Sonars and Other Transducers) are discussed below. The numbers of potential impacts estimated for individual species and stocks of marine mammals from exposure to sonar for training and testing activities under the Proposed Action are shown in Section 5.1 (Incidental Take Request from Acoustic and Explosive Sources) and presented below in figures for each species of marine mammal with any estimated effects (e.g., Figure 6-13). The Activity Categories that are most likely to cause impacts and the most likely region in which impacts could occur are represented in the impact graphics for each species. There is a potential for impacts on occur anywhere within the Study Area where sound from sonar and the species overlap, although only regions or activity categories where 0.5 percent of the impacts or greater are estimated to occur are graphically represented below. All (i.e., grand total) estimated impacts for that species are included, regardless of region or category.

Regions within the NWTT Study Area include (see Study Area maps in Chapter 2, Dates, Duration, and Specified Geographic Region) NWTT Offshore, Dabob Bay Range Complex, Northeast Puget Sound, Southwest Puget Sound, and Southeast Alaska. Note that the numbers of activities planned can vary from year-to-year. Results are presented for a "representative sonar use year" and a "maximum sonar use year" to provide a range of potential impacts that could occur. The number of hours these sonars would be operated annually and for the 7-year period of this request are described in Section 1.5.2 (Summary of Acoustic and Explosive Sources Analyzed for Training and Testing).

It is important to note when examining the results of the quantitative analysis that the behavioral response functions used to predict the numbers of reactions in this analysis are largely derived from several studies (see Section 6.4.1.5, Behavioral Reactions). The best available science, including behavioral response studies, was used for deriving these criteria; however, many of the factors inherent in these studies that potentially increased the likelihood and severity of observed responses (e.g., close approaches by multiple vessels, tagging animals, and vectoring towards animals that have already begun avoiding the sound source) would not occur during Navy activities. Because the Navy purposely avoids approaching marine mammals, many of the behavioral responses estimated by the quantitative analysis are unlikely to occur or unlikely to rise to the severity observed during many of the behavioral response studies.

Although the statutory definition of Level B harassment for military readiness activities under the MMPA requires that the natural behavior patterns of a marine mammal be significantly altered or abandoned, the current state of science for determining those thresholds is somewhat unsettled. Therefore, in its analysis of impacts associated with acoustic sources, the Navy is adopting a conservative approach that overestimates the number of takes by Level B harassment. The responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be

outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As discussed in Section 6.4.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers), the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sound that may exceed an animal's behavioral threshold for only a single exposure to several minutes. It is likely that many of the estimated behavioral reactions within the Navy's quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant versus non-significant behavioral reactions are currently impossible to predict. Consequently, there is a high likelihood that significant numbers of marine mammals exposed to acoustic sources are not significantly altering or abandoning their natural behavior patterns. As such, the overall impact of acoustic sources from military readiness activities on marine mammal species and stocks is negligible (i.e., cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks through effects on annual rates of recruitment or survival).

6.4.2.3.2 Mysticetes

Mysticetes may be exposed to sound from sonar and other transducers associated with training and testing activities throughout the year, although many species are not present in the NWTT Study Area in the summer months. Most low- (less than 1 kHz) and mid- (1–10 kHz) frequency sonars and other transducers produce sounds that are likely to be within the hearing range of mysticetes (Section 6.3, Hearing and Vocalization). Some high-frequency sonars (greater than 10 kHz) also produce sounds that should be audible to mysticetes, although only smaller species of mysticetes such as minke whales are likely to be able to hear higher frequencies, presumably up to 30 kHz. Therefore, some high-frequency sonars and other transducers with frequency ranges between 10 and 30 kHz may also be audible to some mysticetes. If a sound is within an animal's hearing range then behavioral reactions, physiological stress, masking and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss is not likely to occur. Impact ranges for mysticetes are discussed under low-frequency cetaceans in Section 6.4.2 (Impacts from Sonar and Other Transducers).

A few behavioral reactions in mysticetes resulting from exposure to sonar could take place at distances of up to 20 km. Behavioral reactions, however, are much more likely within a few kilometers of the sound source. As discussed above in Section 6.4.2.1.2 (Assessing the Severity of Behavioral Responses from Sonar*)*, the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions. Research shows that if mysticetes do respond they may react in a number of ways, depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Behavioral reactions may include alerting, breaking off feeding dives and surfacing, or diving or swimming away. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be

more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, behavioral reactions from mysticetes are likely to be short term and low to moderate severity.

Behavioral research indicates that mysticetes most likely avoid sound sources at levels that would cause any hearing loss (i.e., TTS) (Section 6.4.1.5, Behavioral Reactions). Therefore, it is likely that the quantitative analysis overestimates TTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Mysticetes that do experience PTS or TTS from sonar sounds may have reduced ability to detect biologically important sounds around the frequency band of the sonar until their hearing recovers. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely 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 (see Section 6.4.1.2, Hearing Loss). Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that a mysticete had 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 at farther ranges 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. A single or even a few minor TTS (less than 20 dB of TTS) to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

Research and observations of masking in marine mammals are discussed in Section 6.4.1.4 (Masking). Most anti-submarine warfare sonars and countermeasures use mid-frequency ranges and a few use low-frequency ranges. Most of these sonar signals are limited in the temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Systems typically operate with low duty cycles for most tactical sources, but some systems may operate nearly continuously or with higher duty cycles. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant masking in mysticetes. High-frequency (greater than 10 kHz) sonars fall outside of the best hearing and vocalization ranges of mysticetes (see Section 6.3, Hearing and Vocalization). Furthermore, high frequencies (above 10 kHz) attenuate more rapidly in the water due to absorption than do lower frequency signals, thus producing only a small zone of potential masking. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). Masking in mysticetes due to exposure to high-frequency sonar is unlikely. Potential costs to mysticetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging, and the effect is over the moment the sound has ceased. By contrast, hearing loss lasts beyond the exposure for a period. Nevertheless, mysticetes that do experience some masking for a short period from low- or mid-frequency sonar may have their ability to communicate with conspecifics reduced, especially at further ranges. However, larger mysticetes (e.g., blue whale, fin whale, sei whale) communicate at frequencies below those of mid-frequency sonar and even most low- frequency sonars. Mysticetes that

communicate at higher frequencies (e.g., minke whale) may be affected by some short-term and intermittent masking. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at further ranges. It is unknown whether masking would affect a mysticete's ability to feed since it is unclear how or if mysticetes use sound for finding prey or feeding. A single or even a few short periods of masking, if it were to occur, to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

Many activities such as submarine under ice certification and most mine hunting exercises use only high-frequency sonars that are not within mysticetes' hearing range; therefore, there were no predicted effects. Section 6.3 (Hearing and Vocalization) discusses low-frequency cetacean (i.e., mysticetes) hearing abilities.

6.4.2.3.2.1 North Pacific Right Whales (Endangered Species Act-Listed)

North Pacific right whales are extremely rare in the Study Area. Data on right whale presence is insufficient to develop density estimates for use in the Navy Acoustic Effects Model for estimating the number of animals that may be exposed to sonars and other transducers. Based on the highly unlikely presence of North Pacific right whales in the offshore portion of the Study Area and no records of occurrence in the inland waters or Behm Canal portions of the Study Area, as well as the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), exposure of any North Pacific right whales to sonars and other transducers associated with training activities is highly unlikely.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

The use of sonar and other transducers during training activities as described under the Proposed Action would not result in the incidental taking of North Pacific right whales.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

The use of sonar and other transducers during testing activities as described under the Proposed Action would not result in the incidental taking of North Pacific right whales.

6.4.2.3.2.2 Blue Whales (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Blue whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions under the Proposed Action (see Figure 6-13 and Table 6-14 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern North Pacific Stock (see Table 6-14).

As described for mysticetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of blue whales incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Blue whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-13 and Table 6-14 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern North Pacific Stock (see Table 6-14).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of blue whales incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-13: Blue Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-14: Estimated Impacts on Individual Blue Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Eastern North Pacific	2	0	0	3	4	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.3 Fin Whales (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Fin whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-14 and Table 6-15 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-15).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of fin whalesincidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Fin whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-14 or Table 6-15. Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-15).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of fin whales incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-14: Fin Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-15: Estimated Impacts on Individual Fin Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Northeast Pacific	0	0	0	1	1	0
California, Oregon, & Washington	41	13	0	44	29	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.4 Sei Whales (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Sei whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-15 and Table 6-16). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern North Pacific stock (see Table 6-16).

There are few predicted impacts relative to the population estimates of the stock expected to be present in the Study Area. As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of sei whales incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Sei whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-15 and Table 6-16 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern North Pacific stock (see Table 6-16).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of sei whales incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-15: Sei Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-16: Estimated Impacts on Individual Sei Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Eastern North Pacific	16	14	0	17	36	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.5 Minke Whales

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Minke whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-16 and Table 6-17 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-17).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of minke whales incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Minke whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-16 and Table 6-17 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-17).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of minke whales incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-16: Minke Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-17: Estimated Impacts on Individual Minke Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Alaska	0	0	0	1	1	0
California, Oregon, & Washington	52	58	0	56	133	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.6 Humpback Whales (some DPSs are Endangered Species Act-Listed)

Impacts have been modeled for the Hawaii (Central North Pacific stock) population of humpback whales, which are not Endangered Species Act-Listed, and for the Mexico (California, Oregon, and Washington stock) and Central America (California, Oregon, and Washington) stock populations of humpback whales, which are Endangered Species Act listed. Western North Pacific humpback whales are not likely to be present in the Study Area during or in proximity to any of the proposed training or testing activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Humpback whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-17 and Table 6-18 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-18).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

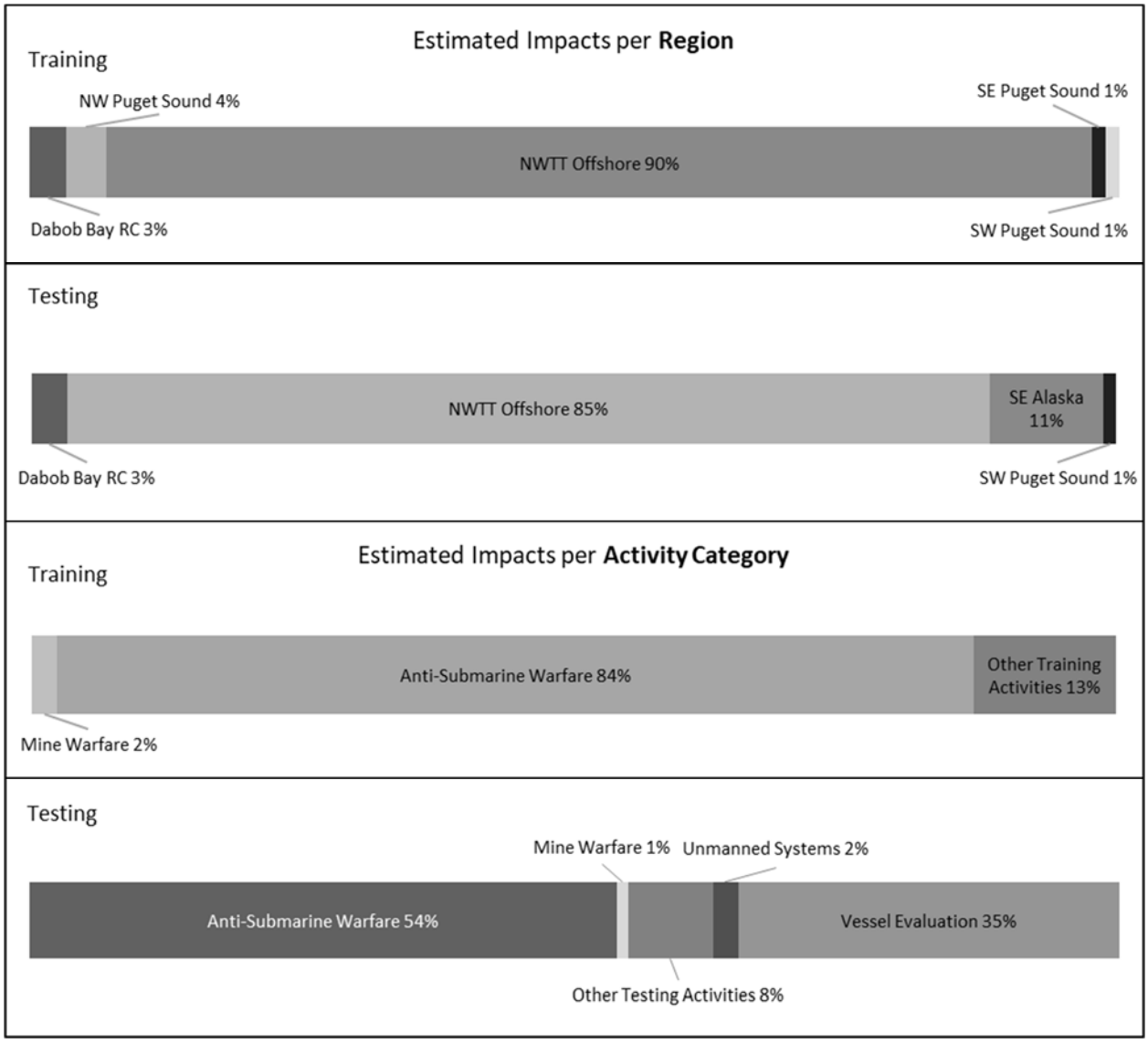
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of humpback whales incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Humpback whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-17 and Table 6-18 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-18).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of humpback whales incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-17: Humpback Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-18: Estimated Impacts on Individual Humpback Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Central North Pacific	3	2	0	46	71	0
California, Oregon, & Washington	3	1	0	38	55	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.7 Gray Whales (one DPS is Endangered Species Act-Listed)

The vast majority of gray whales in the Study Area are from the non-endangered Eastern North Pacific stock. On very rare occasions, Western North Pacific gray whales, which are Endangered Species Act-Listed, occur in the Study Area.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Gray whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions under the Proposed Action (see Figure 6-18 and Table 6-19 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern North Pacific stock (see Table 6-19).

As described for mysticetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of gray whales incidental to those activities.

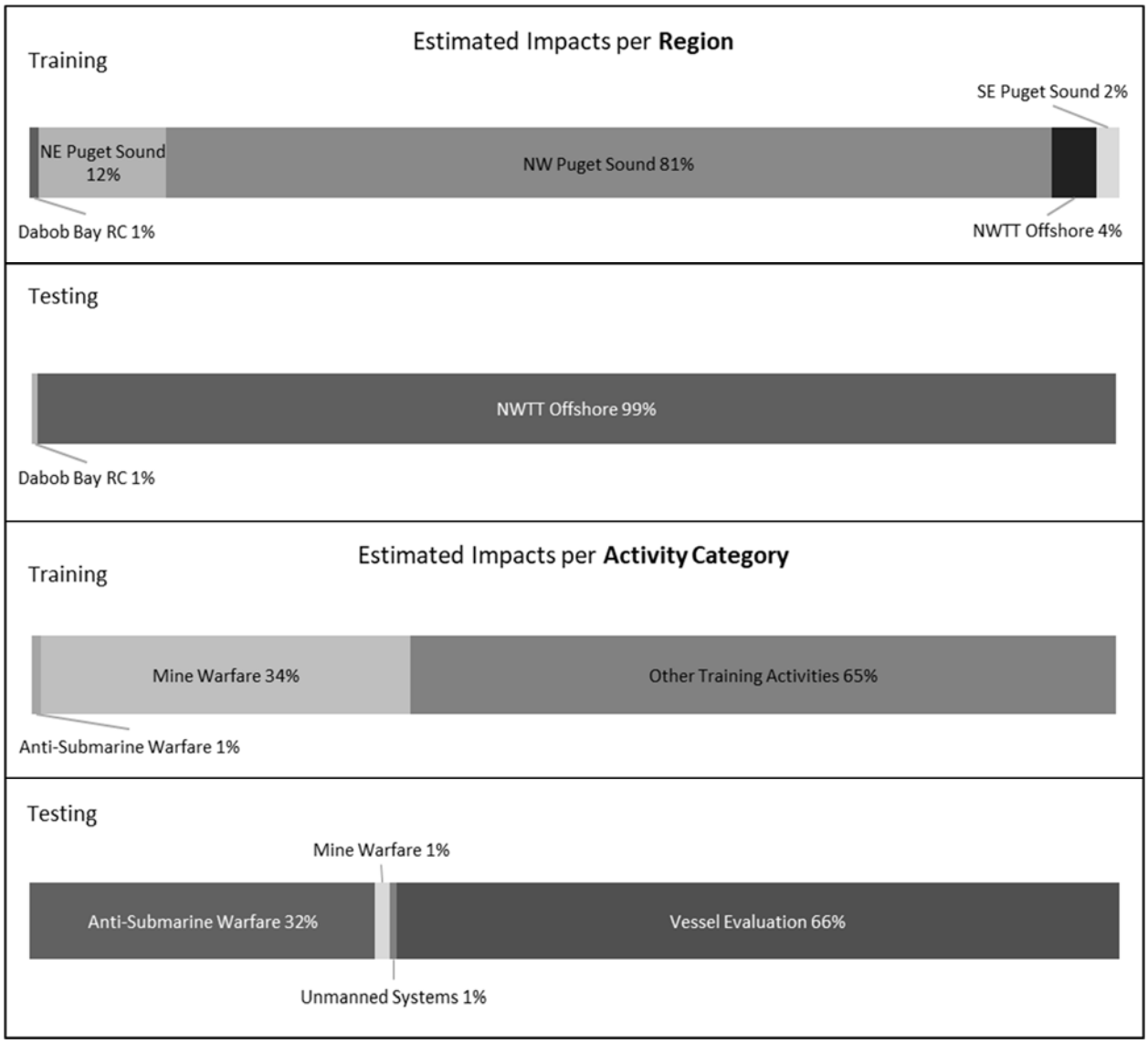
Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Gray whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-18 and Table 6-19). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-19).

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented

as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of gray whales incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-18: Gray Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-19: Estimated Impacts on Individual Gray Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Eastern North Pacific	2	0	0	65	85	0
Western North Pacific	0	0	0	1	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3 Odontocetes

Odontocetes may be exposed to sound from sonar and other transducers associated with training and testing activities throughout the year. Low- (less than 1 kHz), mid- (1–10 kHz), high-frequency (10–100 kHz), and very high-frequency (100–200 kHz) sonars produce sounds that are likely to be within the audible range of odontocetes (see Section 6.3, Hearing and Vocalization). If a sound is within an animal's hearing range then behavioral reactions, physiological stress, masking and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss could not occur. Impact ranges for odontocetes are discussed under mid-frequency cetaceans in Section 6.4.2 (Impacts from Sonar and Other Transducers).

A few behavioral reactions in odontocetes (except beaked whales and harbor porpoise) resulting from exposure to sonar could take place at distances of up to 20 km. Beaked whales and harbor porpoise have demonstrated a high level of sensitivity to human made noise and activity; therefore, the quantitative analysis assumes that some harbor porpoises and some beaked whales could experience significant behavioral reactions at a distance of up to 40 km and 50 km from the sound source, respectively. Behavioral reactions, however, are much more likely within a few kilometers of the sound source for most species of odontocetes such as delphinids and sperm whales. Even for harbor porpoise and beaked whales, as discussed above in Section 6.4.2.1.2 (Assessing the Severity of Behavioral Responses from Sonar), the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions.

Research shows that if odontocetes do respond they may react in a number of ways, depending on the characteristics of the sound source and their experience with the sound source. Behavioral reactions may include alerting, breaking off feeding dives and surfacing, or diving or swimming away. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, most behavioral reactions from odontocetes are likely to be short term and low to moderate severity.

Large odontocetes such as killer whales and pilot whales have been the subject of behavioral response studies (see Section 6.4.1.5, Behavioral Reactions). Based on these studies, a number of reactions could occur, such as a short-term cessation of natural behavior (e.g., feeding, avoidance of the sound source, or even attraction towards the sound source as seen in pilot whales). Due to the factors involved in Navy training and testing exercises versus the conditions under which pilot whales and killer whales were exposed during behavioral response studies, large odontocetes are unlikely to have more than short-

term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few kilometers. Most estimated impacts are due to anti-submarine warfare activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and maintenance typically last for a few hours and involve a limited amount of sonar use, so significant responses would be less likely to occur due to the limited duration.. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Small odontocetes have been the subject of behavioral response studies and observations in the field (see Section 6.4.1.5, Behavioral Reactions). Based on these studies, small odontocetes (dolphins) appear to be less sensitive to sound and human disturbance than other cetacean species. If reactions did occur, they could consist of a short-term behavioral response such as cessation of feeding, avoidance of the sound source, or even attraction towards the sound source. Small odontocetes are unlikely to have more than short-term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few kilometers. Most estimated impacts are due to anti-submarine warfare activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and maintenance typically last for a few hours and involve a limited amount of sonar use, so significant responses would be less likely due to the limited duration. Some bottlenose dolphin estimated impacts could also occur due to navigation and object avoidance (detection) since these activities typically occur entering and leaving Navy homeports that overlap the distribution of coastal populations of this species. Navigation and object avoidance (detection) activities normally involve a single ship or submarine using a limited amount of sonar; therefore, significant reactions are unlikely. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Behavioral research indicates that most odontocetes avoid sound sources at levels that would cause any temporary hearing loss (i.e., TTS) (see Section 6.4.1.5, Behavioral Reactions). TTS and even PTS is more likely for high-frequency cetaceans, such as harbor porpoises and Kogia whales, because hearing loss thresholds for these animals are lower than for all other marine mammals. These species, especially harbor porpoises, have demonstrated a high level of sensitivity to human-made sound and activities and may avoid them at further distances. This increased distance could avoid or minimize hearing loss for these species as well, especially as compared to the estimates from the quantitative analysis. Therefore, it is likely that the quantitative analysis overestimates TTS and PTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable, and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely 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. Threshold shifts do not necessarily affect all hearing frequencies equally and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that an odontocete had hearing loss, social calls from conspecifics could be more difficult to detect or interpret. Killer whales are a primary predator of odontocetes. Some hearing loss could make killer whale calls more difficult to detect at further ranges until hearing recovers. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few tens of kHz for delphinids, beaked whales, and sperm whales, and above 100 kHz for porpoises and Kogia whales. Therefore, echolocation associated with feeding and navigation in odontocetes is unlikely to be affected by threshold shift at lower frequencies

and should not have any significant effect on an odontocete's ability to locate prey or navigate, even in the short term. Therefore, a single or even a few minor TTS (less than 20 dB of TTS) to an individual odontocete per year are unlikely to have any long-term consequences for that individual. Minor PTS (a few dB or less) in an individual could have no to minor long-term consequences for individuals.

Research and observations of masking in marine mammals are discussed in Section 6.4.1.4 (Masking). Many anti-submarine warfare sonars and countermeasures use low- and mid-frequency sonar. Most low- and mid-frequency sonar signals (i.e., sounds) are limited in their temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically much less than one-third octave). These factors reduce the likelihood of sources causing significant masking in odontocetes due to exposure to sonar used during anti-submarine warfare activities. Odontocetes may experience some limited masking at closer ranges from high-frequency sonars and other transducers; however, the frequency band of the sonar is narrow, limiting the likelihood of masking. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). Potential costs to odontocetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased.

Nevertheless, odontocetes that do experience some masking from sonar or other transducers may have their ability to communicate with conspecifics reduced, especially at further ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at further ranges. As discussed above for TTS, odontocetes use echolocation to find prey and navigate. The echolocation clicks of odontocetes are above the frequencies of most sonar systems, especially those used during anti-submarine warfare. Therefore, echolocation associated with feeding and navigation in odontocetes is unlikely to be masked by sounds from sonars or other transducers. A single or even a few short periods of masking, if it were to occur, to an individual odontocete per year are unlikely to have any long-term consequences for that individual.

6.4.2.3.3.1 Common Bottlenose Dolphins

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Common bottlenose dolphins may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions under the Proposed Action (see Figure 6-19 and Table 6-20 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-20).

As described for odontocetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

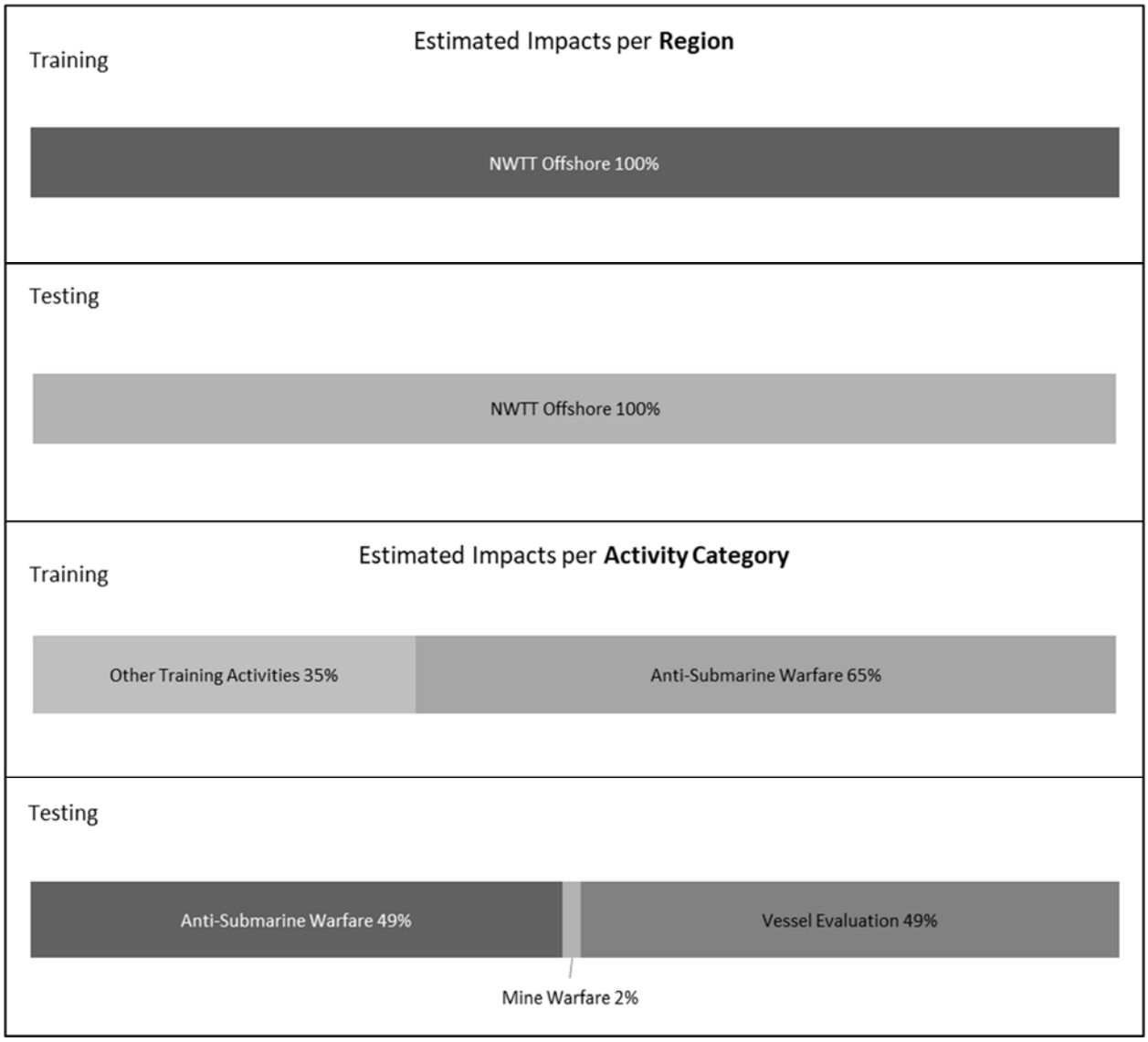
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of common bottlenose dolphins incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Common bottlenose dolphins may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions under the Proposed Action (see Figure 6-19 and Table 6-20 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-20).

As described for odontocetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of common bottlenose dolphins incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-19: Common Bottlenose Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-20: Estimated Impacts on Individual Common Bottlenose Dolphin Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington, Offshore	5	0	0	3	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.2 Killer Whales (one DPS is Endangered Species Act-Listed)

For the populations of killer whales present in the Study Area, only the Southern Resident population is listed as endangered under the ESA.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Killer whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-20 and Table 6-21). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-21).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

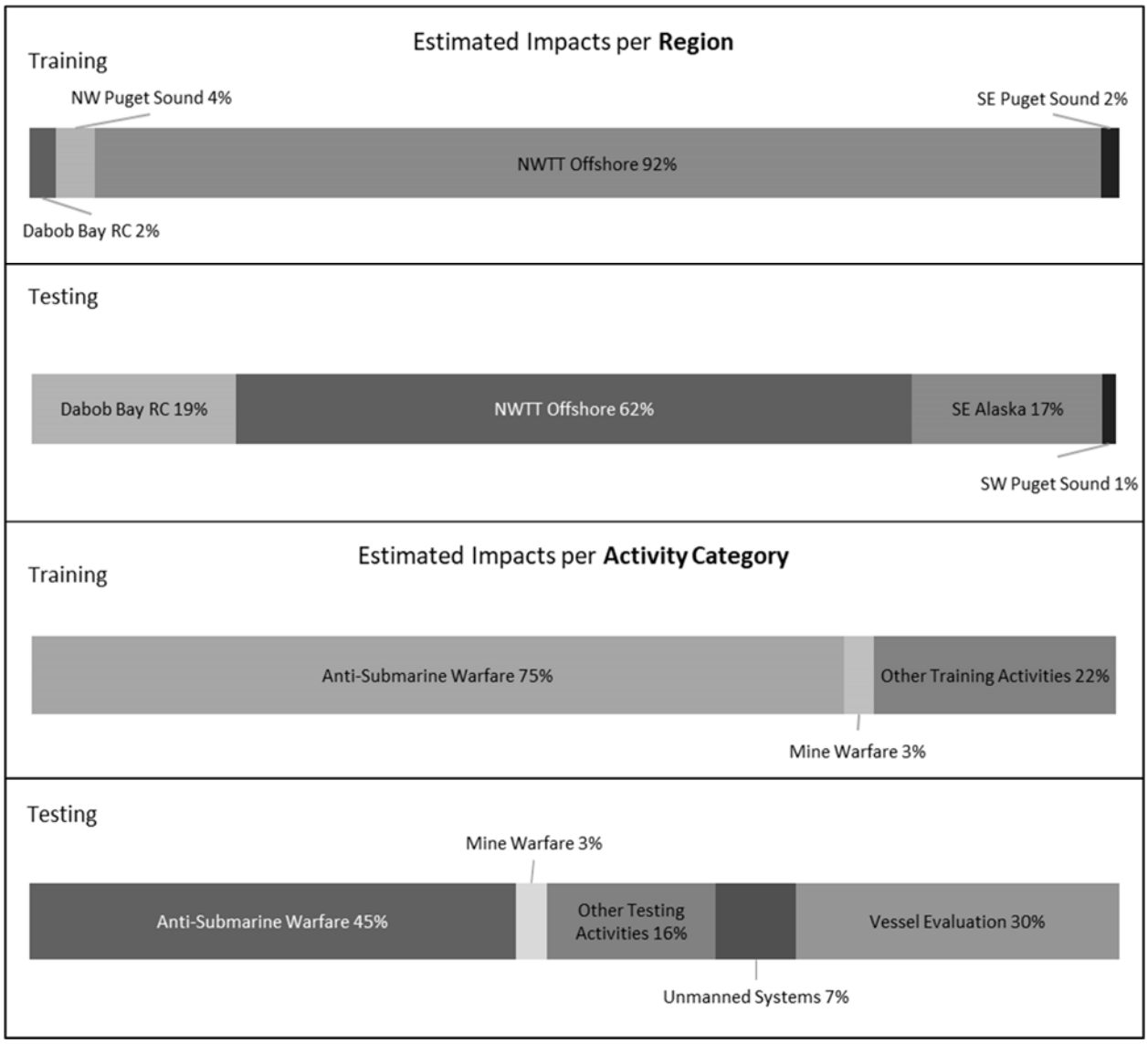
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of killer whales incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Killer whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-20 and Table 6-21 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-21).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of killer whales incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-20: Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-21: Estimated Impacts on Individual Killer Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Alaska Resident	0	0	0	34	0	0
Eastern North Pacific Offshore	67	1	0	86	4	0
Northern Resident	0	0	0	0	0	0
West Coast Transient	76	2	0	136	20	0
Southern Resident	2	0	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.3 Northern Right Whale Dolphins

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Northern right whale dolphins may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-21 and Table 6-22 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-22).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

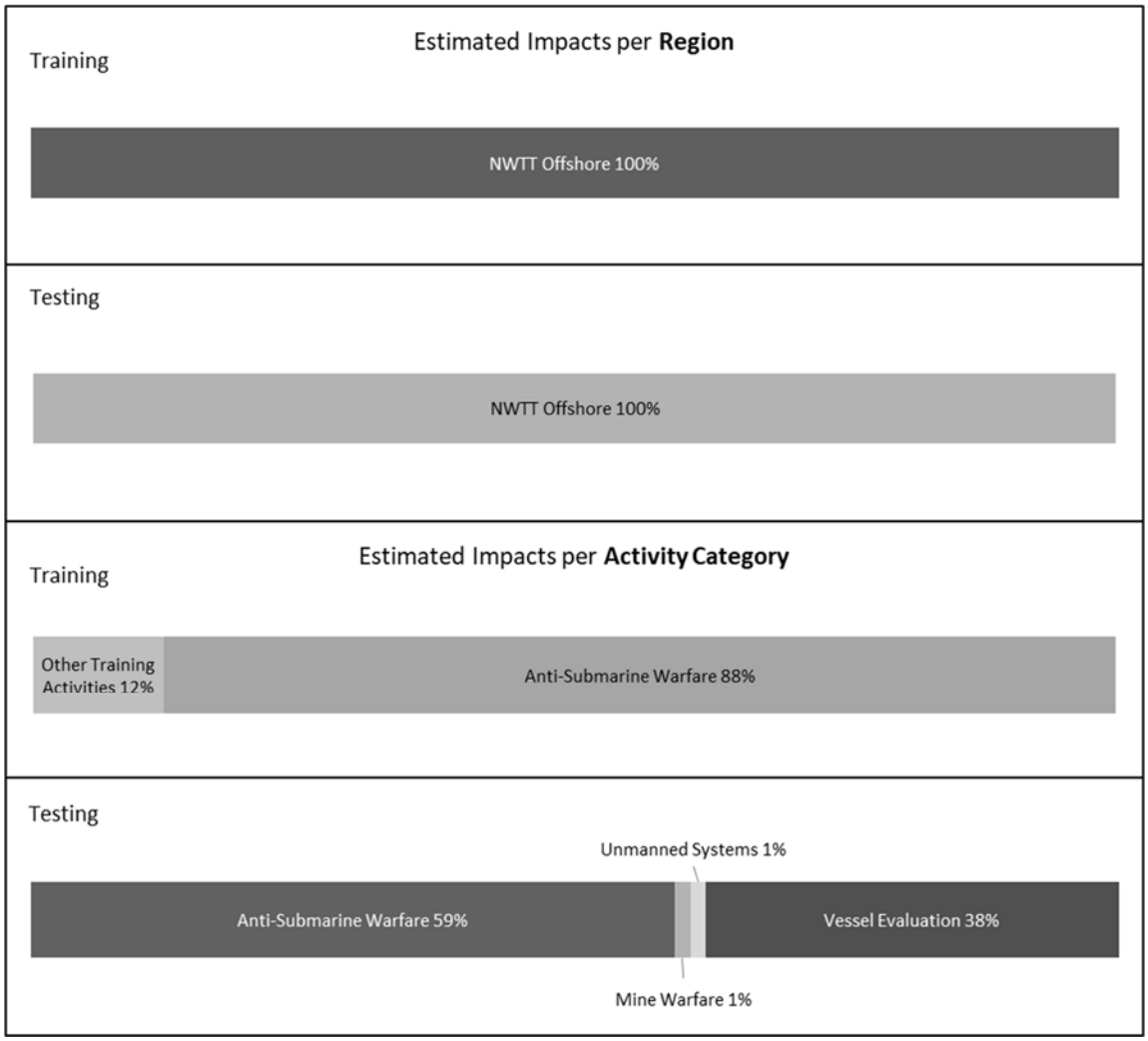
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Northern right whale dolphins incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Northern right whale dolphins may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under the Proposed Action (see Figure 6-21 and Table 6-22 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-22).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS, if it were to occur, would leave some residual hearing loss after recovery from the initial threshold shift. Minor PTS (a few dB or less) in an individual could have no to minor long-term consequences for individuals. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Northern right whale dolphins incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-21: Northern Right Whale Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-22: Estimated Impacts on Individual Northern Right Whale Dolphin Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	7,785	156	0	12,018	847	1

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.4 Pacific White-Sided Dolphins

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Pacific white-sided dolphins may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-22 and Table 6-23). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-23).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

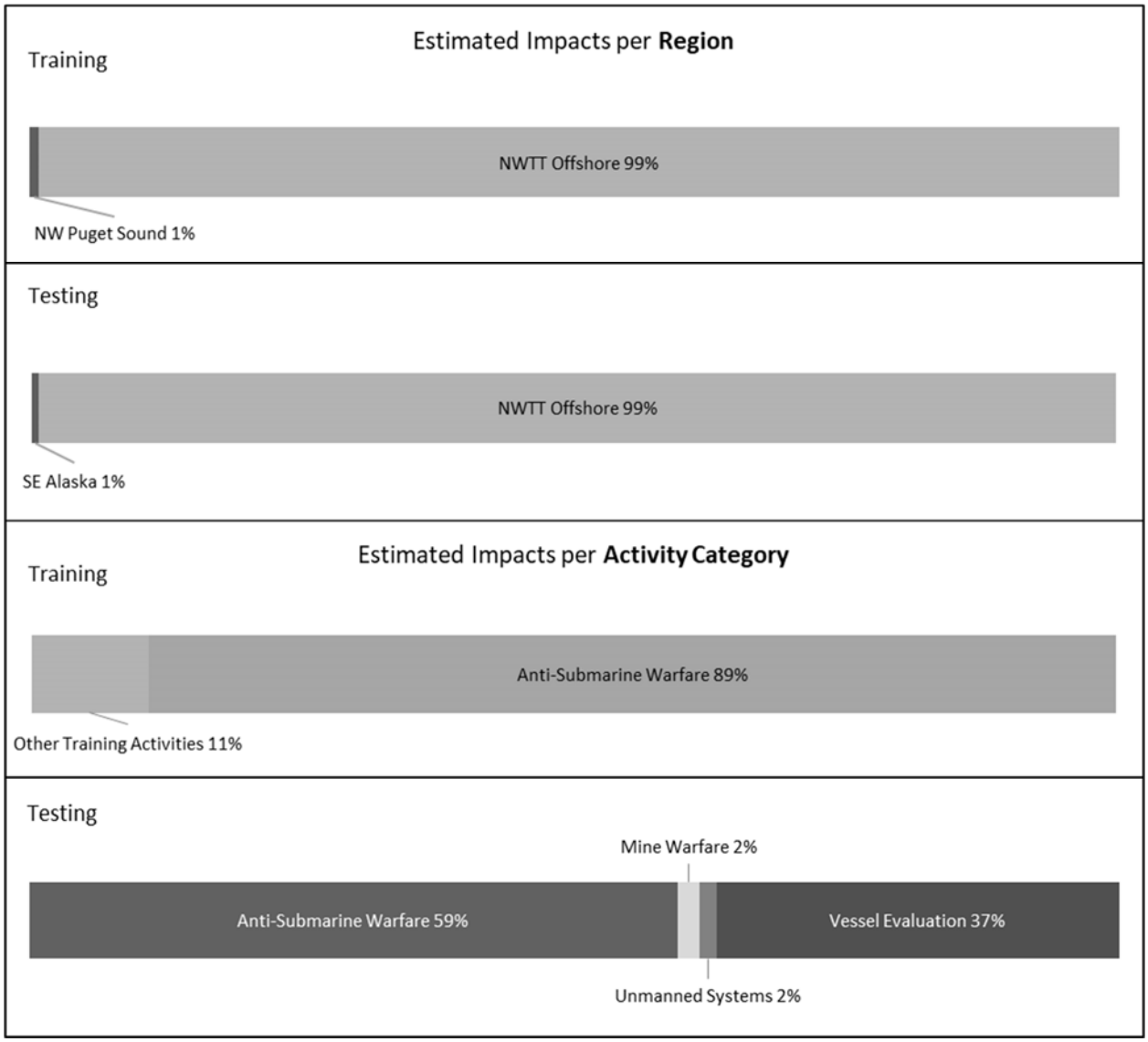
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Pacific white-sided dolphins incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Pacific white-sided dolphins may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under the Proposed Action (see Figure 6-22 and Table 6-23 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-23).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS, if it were to occur, would leave some residual hearing loss after recovery from the initial threshold shift. Minor PTS (a few dB or less) in an individual could have no to minor long-term consequences for individuals. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Pacific white-sided dolphins incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-22: Pacific White-Sided Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-23: Estimated Impacts on Individual Pacific White-Sided Dolphin Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
North Pacific	0	0	0	101	0	0
California, Oregon, & Washington	5,198	86	0	13,809	1,278	1

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.5 Risso's Dolphins

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Risso's dolphins may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-23 and Table 6-24 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-24).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

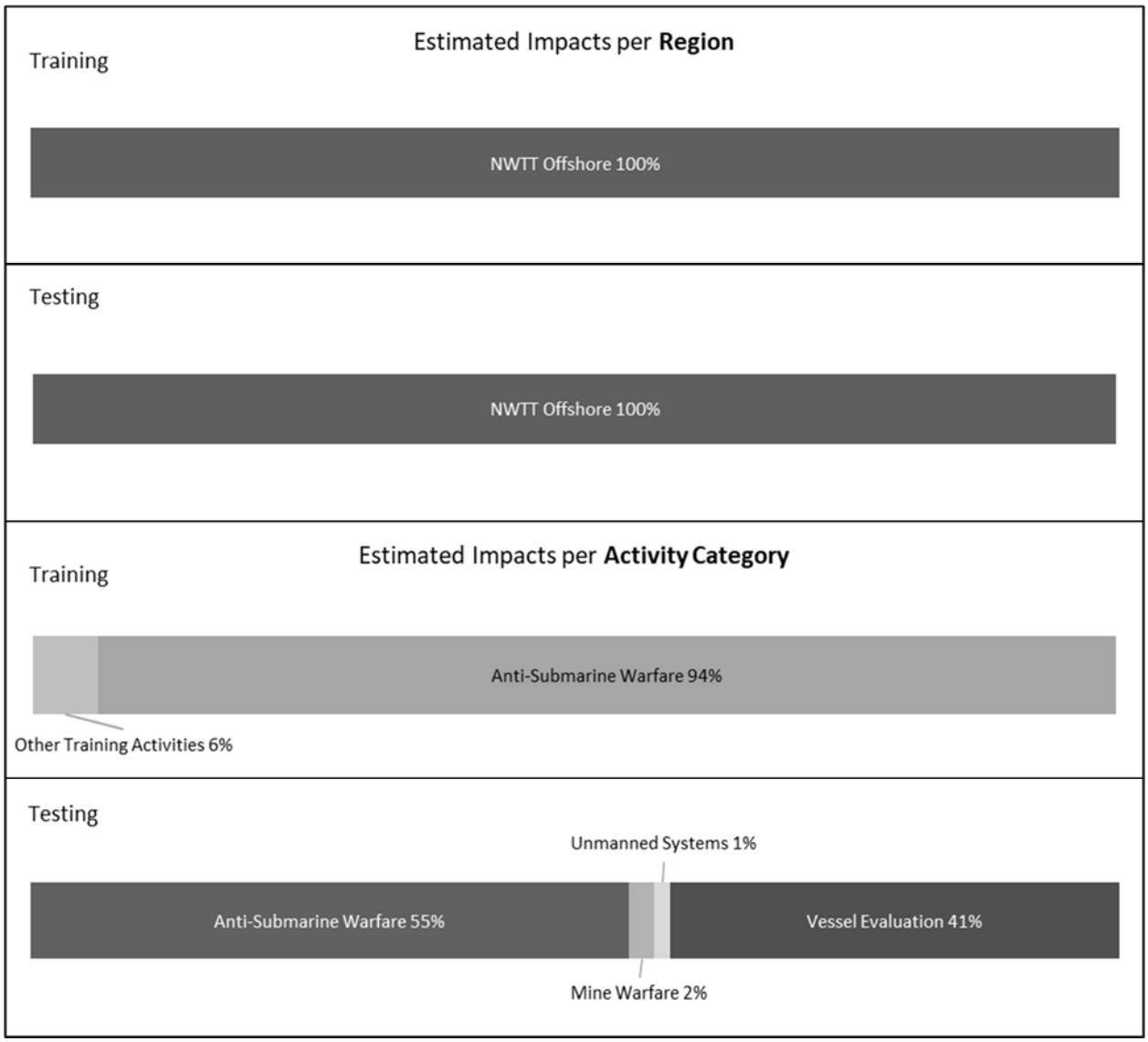
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Risso's dolphins incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Risso's dolphins may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-23 and Table 6-24 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-24).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Risso's dolphins incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-23: Risso's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-24: Estimated Impacts on Individual Risso's Dolphin Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	2,240	46	0	3,920	248	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.6 Short-Beaked Common Dolphin

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Short-beaked common dolphins may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-24 and Table 6-25 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-25).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of short-beaked common dolphins incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Short-beaked common dolphins may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-24 and Table 6-25 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-25).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of short-beaked common dolphins incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-24: Short-Beaked Common Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-25: Estimated Impacts on Individual Short-Beaked Common Dolphin Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	1,140	25	0	963	21	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.7 Short-Finned Pilot Whales

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Short-finned pilot whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions under the Proposed Action (see Figure 6-25 and Table 6-26 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-26).

As described for odontocetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of short-finned pilot whales incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Short-finned pilot whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-25 and Table 6-26 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-26).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of short-finned pilot whales incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-25: Short-Finned Pilot Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-26: Estimated Impacts on Individual Short-Finned Pilot Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	57	0	0	31	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.8 Striped Dolphins

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Striped dolphins may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-26 and Table 6-27 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-27).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of striped dolphins incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Striped dolphins may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-26 and Table 6-27 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-27).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of striped dolphins incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-26: Striped Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-27: Estimated Impacts on Individual Striped Dolphin Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	*Training*			*Testing*		
	Behavioral	*TTS*	*PTS*	*Behavioral*	*TTS*	*PTS*
California, Oregon, & Washington	426	13	0	336	7	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.9 Kogia Whales

Kogia whales include two species that are often difficult to distinguish from one another: dwarf sperm whales and pygmy sperm whales; however, impacts to the populations of dwarf and pygmy sperm whales are modeled separately.

TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales, are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Kogia whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-27, Figure 6-28, Table 6-28, and Table 6-29 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts to Kogia whales (pygmy and dwarf sperm whales) apply only to the California, Oregon, and Washington stock (see Table 6-28 and Table 6-29).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

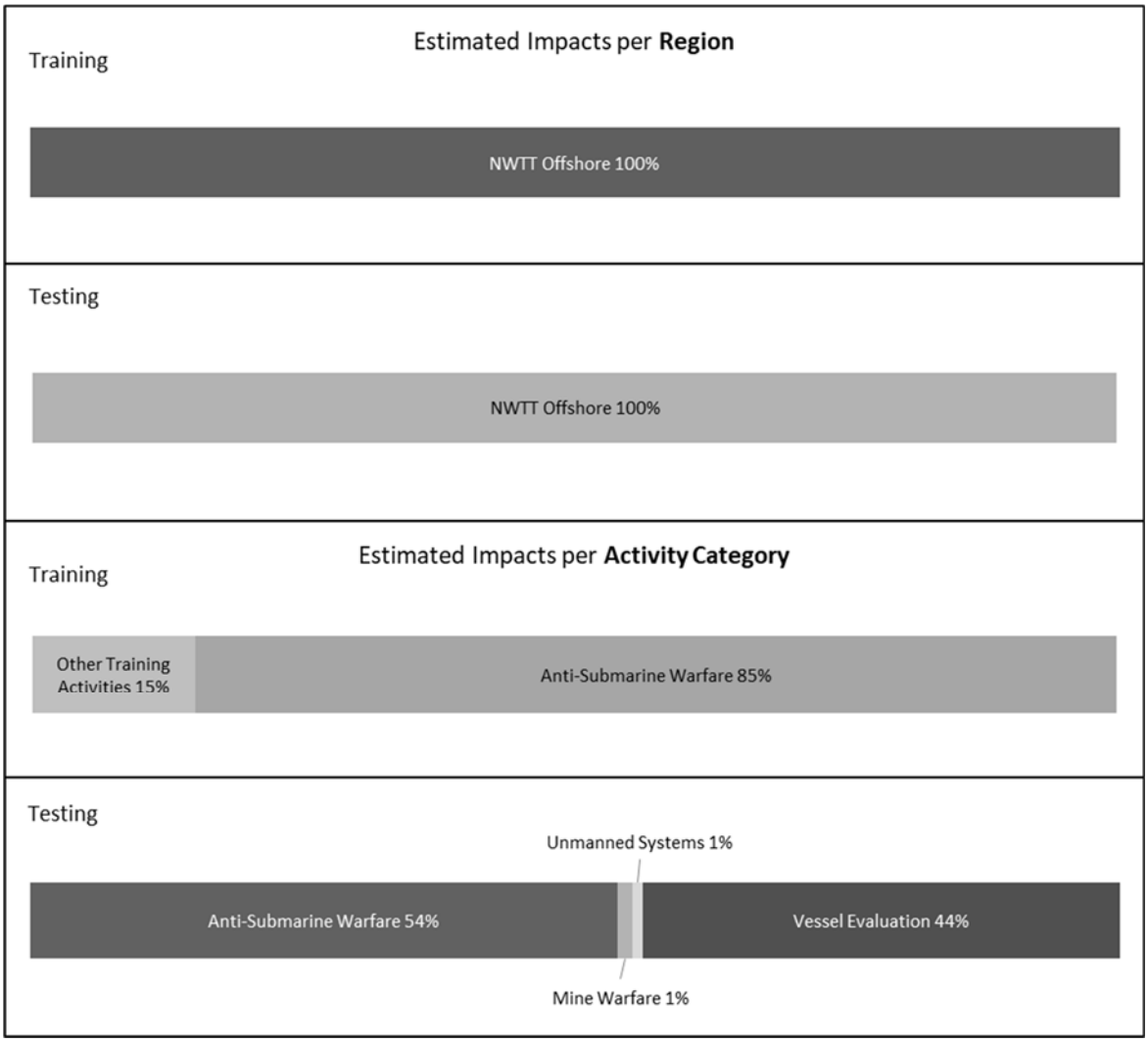
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Kogia whales (i.e., dwarf and pygmy sperm whales) incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Kogia whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-27, Figure 6-28 , Table 6-28, and Table 6-29 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated

impacts to Kogia whales (pygmy and dwarf sperm whales) apply only to the California, Oregon, and Washington stock (see Table 6-28 and Table 6-29).
As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Kogia whales (i.e., dwarf and pygmy sperm whales) incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-27: Dwarf Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-28: Estimated Impacts on Individual Dwarf Sperm Whale Stocks Within the Study Area per Year from Explosions Used During Training and Testing Under the Proposed Action.

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	20	18	0	16	34	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-28: Pygmy Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-29: Estimated Impacts on Individual Pygmy Sperm Whale Stocks Within the Study Area per Year from Explosions Used During Training and Testing Under the Proposed Action.

Estimated Impacts by Effect						
Stock	*Training*			*Testing*		
	Behavioral	*TTS*	*PTS*	*Behavioral*	*TTS*	*PTS*
California, Oregon, & Washington	183	160	0	145	306	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.10 Dall's Porpoises

TTS and PTS thresholds for high-frequency cetaceans, including Dall's porpoises, are lower than for all other marine mammals, which leads to a higher number of estimated impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans). The information available on harbor porpoise behavioral reactions to human disturbance (a closely related species) suggests that these species may be more sensitive and avoid human activity and sound sources to a longer range than most other odontocetes. This would make Dall's porpoises less susceptible to hearing loss; therefore, it is likely that the quantitative analysis over-predicted hearing loss impacts (i.e., TTS and PTS) in Dall's porpoises.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Dall's porpoises may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under the Proposed Action (see Figure 6-29 and Table 6-30 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-30).

As described for odontocetes above, even a few TTS or behavioral reactions in an individual animal within a given year are unlikely to have any long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely, and a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that Dall's porpoise rely upon if it did occur. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Dall's porpoises incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Dall's porpoises may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under the Proposed Action (see Figure 6-29 and Table 6-30 below). Impact ranges for this species are

discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-30).

As described for odontocetes above, even a few TTS or behavioral reactions in an individual animal within a given year are unlikely to have any long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely, and a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that Dall's porpoise rely upon if it did occur. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stocks. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Dall's porpoises incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-29: Dall's Porpoise Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-30: Estimated Impacts on Individual Dall's Porpoise Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Alaska	0	0	0	179	459	0
California, Oregon, & Washington	6,911	6,368	6	6,530	13,837	25

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.11 Harbor Porpoises

TTS and PTS thresholds for high-frequency cetaceans, including harbor porpoise, are lower than for all other marine mammals, which leads to a higher number of estimated impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans). Harbor porpoises are particularly sensitive to human-made noise and disturbance and will avoid sound levels between 120 and 140 dB re 1 μPa at distances up to 30 km for more intense activities (as discussed below). This means that the quantitative analysis greatly overestimates hearing loss in harbor porpoises because most animals would avoid sound levels that could cause TTS or PTS.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Harbor porpoises may be exposed to sound from sonar and other transducers used during training activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS per year under the Proposed Action (see Figure 6-30 and Table 6-30). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the multiple stocks (see Table 6-31).

As described for odontocetes above, even a few TTS or behavioral reactions in an individual animal within a given year are unlikely to have any long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely, and a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that harbor porpoise rely upon if it did occur. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stocks. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

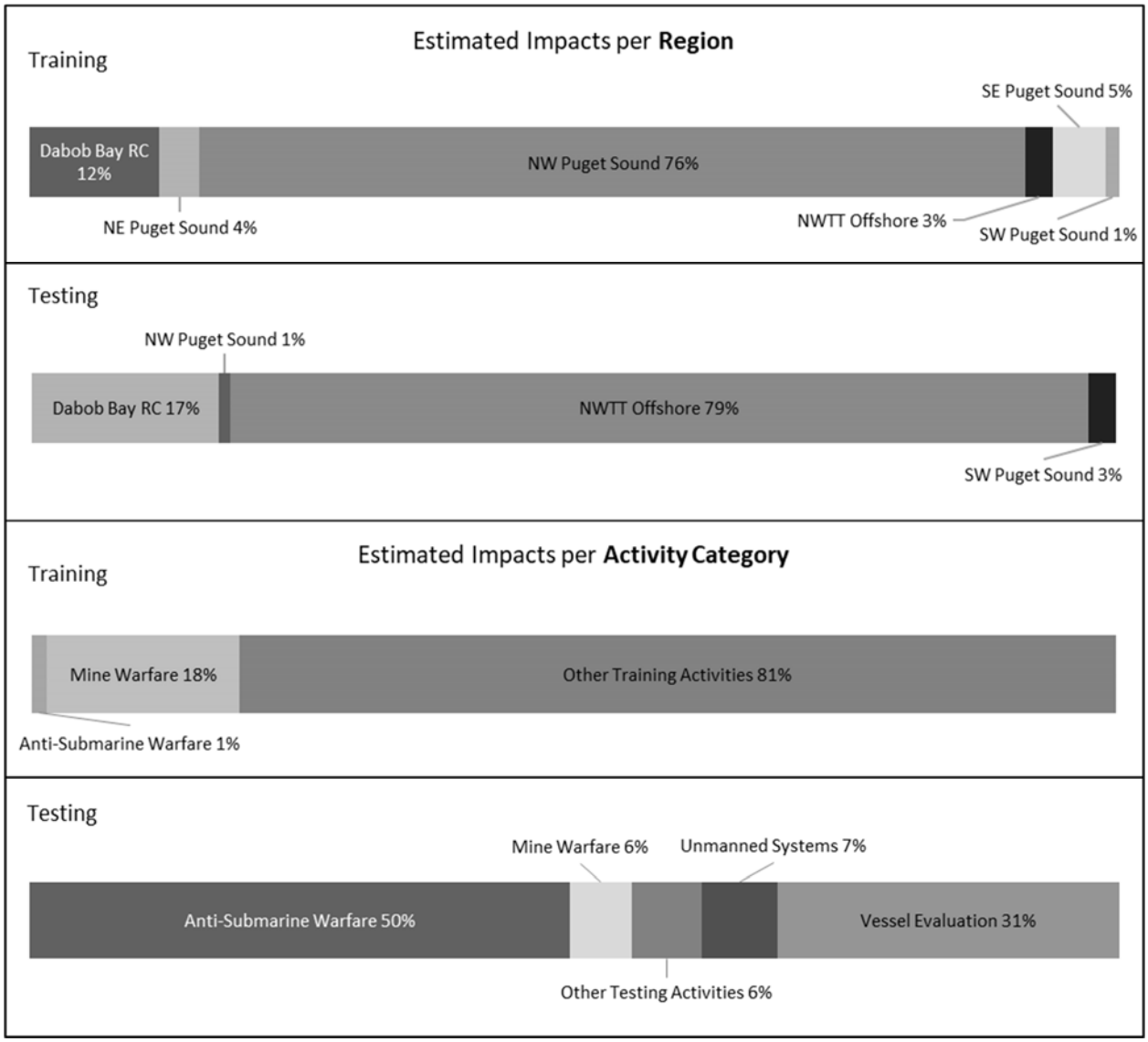
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of harbor porpoises incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Harbor porpoises may be exposed to sound from sonar and other transducers used during testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS per year under the Proposed Action (see Figure 6-30 and Table 6-30 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the multiple stocks (see Table 6-31).

As described for odontocetes above, even a few TTS or behavioral reactions in an individual animal within a given year are unlikely to have any long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely, and a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that harbor porpoise rely upon if it did occur. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stocks. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of harbor porpoises incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-30: Harbor Porpoise Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-31: Estimated Impacts on Individual Harbor Porpoise Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Southeast Alaska	0	0	0	92	38	0
Northern Oregon/ Washington Coast	212	87	0	39,304	24,976	34
Northern California/ Southern Oregon	21	0	0	1,579	134	0
Washington Inland Waters	8,010	4,244	16	7,353	10,284	137

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.12 Sperm Whales (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Sperm whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-31 and Table 6-32 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-32).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of sperm whales incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Sperm whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-31 and Table 6-32 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-32).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented

as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of sperm whales incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-31: Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-32: Estimated Impacts on Individual Sperm Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	510	2	0	319	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.13 Beaked Whales

Beaked whales within the NWTT study area include Baird's beaked whale, Blainville's beaked whale, Cuvier's beaked whale, Hubb's beaked whale, Ginkgo-toothed beaked whale, Perrin's beaked whale, Stejneger's beaked whale, and the Pygmy beaked whale. Impacts to Blainville's beaked whale, Hubb's beaked whale, Ginkgo-toothed beaked whale, Perrin's beaked whale, Stejneger's beaked whale and the Pygmy beaked whale are combined and represented in the beaked whale guild (*Mesoplodon spp*.).

As discussed above for odontocetes overall, the quantitative analysis overestimates hearing loss in marine mammals because behavioral response research has shown that most marine mammals are likely to avoid sound levels that could cause more than minor to moderate TTS (6–20 dB). Specifically for beaked whales, behavioral response research discussed below and in Section 6.4.1.5 (Behavioral Reactions) has demonstrated that beaked whales are sensitive to sound from sonars and usually avoid sound sources by 10 or more kilometers. These are well beyond the ranges to TTS for mid-frequency cetaceans such as beaked whales. Therefore, any TTS predicted by the quantitative analysis is unlikely to occur in beaked whales.

Research and observations (Section 6.4.1.5, Behavioral Reactions) show that if beaked whales are exposed to sonar or other transducers they may startle, break off feeding dives, and avoid the area of the sound source at levels ranging between 95 and 157 dB re 1 μPa (McCarthy et al., 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas and Hawaii, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends (Henderson et al., 2015; Henderson et al., 2016; Manzano-Roth et al., 2016; Tyack et al., 2011). Populations of beaked whales and other odontocetes on Navy fixed ranges that have been operating for decades appear to be stable, and analysis is ongoing. Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers, especially for prolonged periods (a few hours or more) since this is one of the most sensitive marine mammal groups to human-made sound of any species or group studied to date.

Based on the best available science, the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other transducers during training or testing activities would generally not have long-term consequences for individuals or populations. However, because of a lack of scientific consensus regarding the causal link between sonar and stranding events, NMFS has stated in a letter to the Navy dated October 2006 that it "cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality." The Navy

does not anticipate that marine mammal strandings or mortality will result from the operation of sonar during Navy exercises within the Study Area. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the event that a causal relationship were to be found between Navy activities and a future stranding.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Beaked whales may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-32 through Figure 6-34 and Table 6-33, through Table 6-35 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts to Baird's beaked whales, Cuvier's beaked whale, and the small beaked whale guild (*Mesoplodon spp*.) apply to the California, Oregon, and Washington stocks (see Table 6-33, Table 6-34, and Table 6-35).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Baird's, Cuvier's, and Mesoplodon spp. beaked whales (species within the beaked whale guild) incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Beaked whales may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-32 through Figure 6-34 and Table 6-33, through Table 6-35 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts to Baird's beaked whales, Cuvier's beaked whale, and the small beaked whale guild (*Mesoplodon spp*.) apply to the California, Oregon, and Washington stock (see Table 6-33, Table 6-34, and Table 6-35).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Baird's, Cuvier's, and Mesoplodon spp. beaked whales (species within the beaked whale guild) incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-32: Baird's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-33: Estimated Impacts on Individual Baird's Beaked Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	556	0	0	420	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-33: Cuvier's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-34: Estimated Impacts on Individual Cuvier's Beaked Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action.

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	1,461	1	0	1,072	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-34: Mesoplodon Spp. (Small Beaked Whale Guild) Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-35: Estimated Impacts on Individual Mesoplodon Spp. (Small Beaked Whale Guild) Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	651	1	0	467	2	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.4 Pinnipeds

Pinnipeds include phocid seals (true seals) and otariids (sea lions and fur seals).

Pinnipeds may be exposed to sound from sonar and other transducers associated with training and testing activities throughout the year. Low- (less than 1 kHz), mid- (1–10 kHz), and high-frequency (10–100 kHz) sonars produce sounds that are likely to be within the audible range of pinnipeds (see Section 6.3, Hearing and Vocalization). If a sound is within an animal's hearing range then behavioral reactions, physiological stress, masking, and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss could not occur. Impact ranges for pinnipeds are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

A few behavioral reactions by pinnipeds resulting from exposure to sonar could take place at distances of up to 10 km. Behavioral reactions, however, are much more likely within a kilometer or less of the sound source (see Section 6.4.1.5, Behavioral Reactions). As discussed above in Section 6.4.2.1.2 (Assessing the Severity of Behavioral Responses from Sonar), the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions. Research shows that pinnipeds in the water are generally tolerant of human made sound and activity (see Section 6.4.1.5, Behavioral Reactions). If pinnipeds are exposed to sonar or other transducers, they may react in various ways, depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Pinnipeds may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individual pinnipeds from a single or several impacts per year are unlikely.

Behavioral research indicates that most pinnipeds probably avoid sound sources at levels that could cause higher levels of TTS (greater than 20 dB of TTS) and PTS. Recovery from TTS begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. Most TTS, if it does actually occur, would be more likely 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. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the short period that a pinniped had TTS, social calls from conspecifics could be more difficult to detect or interpret. Killer whales are a primary predator of pinnipeds. Some TTS could make killer whale calls more difficult to detect at further ranges until hearing recovers. Pinnipeds probably use sound and vibrations to find and capture prey underwater. Therefore, it could be more difficult for pinnipeds with TTS to locate food for a short period before their hearing recovers. Because TTS would likely be minor to moderate (less than 20 dB of TTS), costs would be short-term and could be recovered. A single or even a few mild to moderate TTS per year are unlikely to have any long-term consequences for that individual.

Research and observations of masking in marine mammals are discussed in Section 6.4.1.4 (Masking). Many low- (less than 1 kHz), mid- (1–10 kHz), and high-frequency (10–100 kHz) sonars produce sounds that are likely to be within the hearing range of pinnipeds. Many anti-submarine warfare (anti-submarine warfare) sonars and countermeasures use low- and mid-frequency ranges. Most low- and mid-frequency sonar signals (i.e., sounds) are limited in the temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant masking in pinnipeds due to exposure to sonar used during anti-submarine warfare activities. Pinnipeds may experience some limited masking at closer ranges from high-frequency sonars and other transducers; however, the frequency band of these sourcesis narrow, limiting the likelihood of masking. Sources that employ high frequencies are typically used for mine hunting, navigation, and object detection (avoidance). Potential costs to pinnipeds from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively transmitting, and the effect is over the moment the sound has ceased. Nevertheless, pinnipeds that do experience some masking for a short period from sonar or other transducers may have their ability to communicate with conspecifics reduced, especially at further ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations, making predators more difficult to detect, especially at further ranges. Pinnipeds probably use sound and vibrations to find and capture prey underwater. Therefore, it could be more difficult for pinnipeds to locate food if masking is occurring. A single or even a few short periods of masking, if it were to occur, to an individual pinniped per year are unlikely to have any long-term consequences for that individual.

6.4.2.3.4.1 California Sea Lions

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

California sea lions may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-35 and Table 6-36 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the U.S. stock (see Table 6-36).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

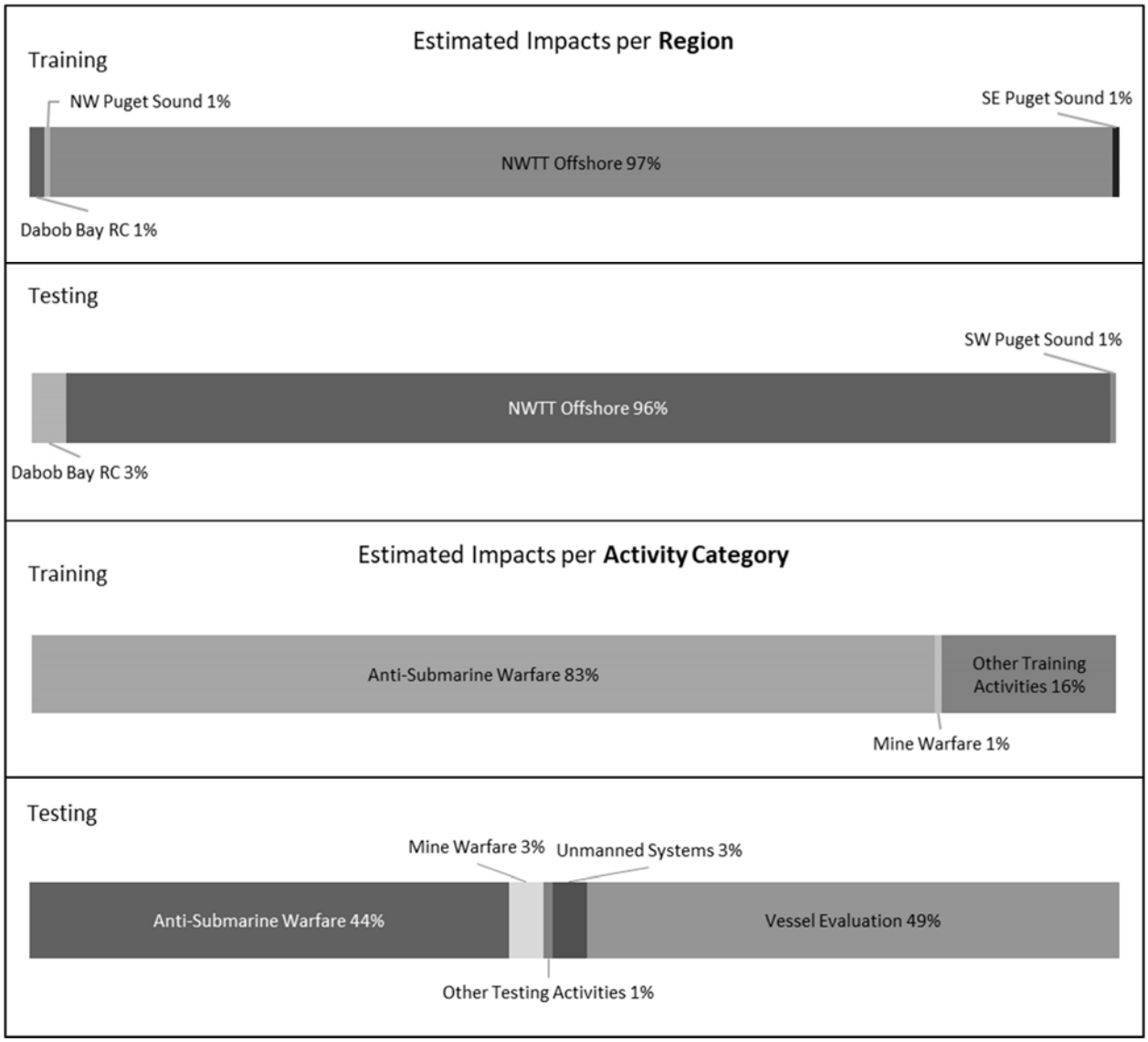
The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of California sea lions incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

California sea lions may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-35 and Table 6-36 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the U.S. stock (see Table 6-36).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of California sea lions incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-35: California Sea Lion Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-36: Estimated Impacts on Individual California Sea Lion Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action.

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
U.S. Stock	3,615	9	0	23,653	337	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.4.2 Steller Sea Lions (one DPS is Endangered Species Act-Listed)

The Eastern U.S. stock of Steller sea lions is not listed under the Endangered Species Act. All impacts estimated by the quantitative analysis are on the Eastern U.S. stock. The Western U.S. stock of Steller sea lions is listed endangered under the ESA; however, Steller sea lions from the Western U.S. stock are rare in the Study Area.

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Steller sea lions may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-36 and Table 6-37 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern U.S. stock (see Table 6-37).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Steller sea lions incidental to those activities.

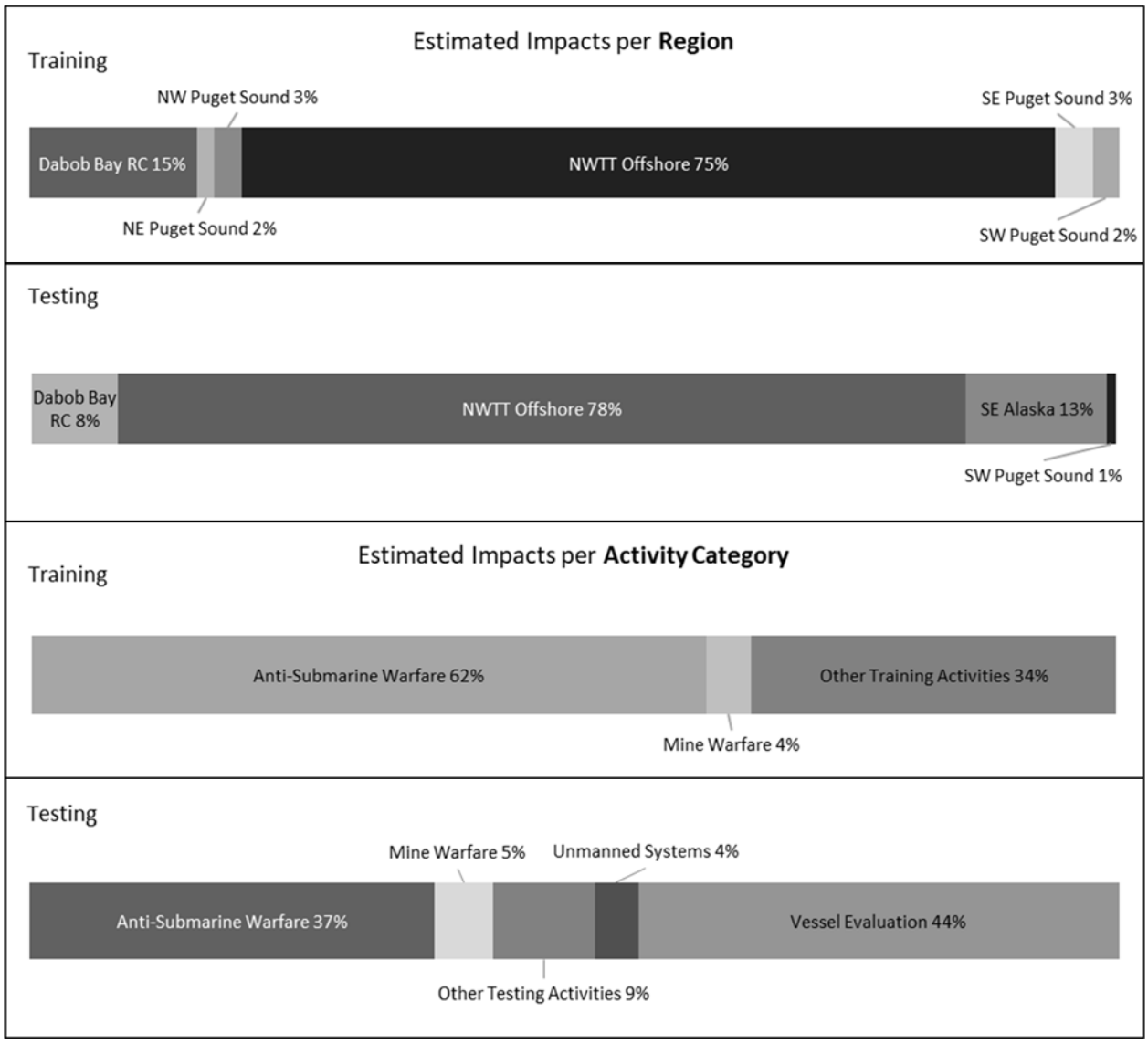
Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Steller sea lions may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-36 and Table 6-37 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern U.S. stock (see Table 6-37).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as

described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Steller sea lions incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-36: Steller Sea Lion Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-37: Estimated Impacts on Individual Steller Sea Lion Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	*Training*			*Testing*		
	Behavioral	*TTS*	*PTS*	*Behavioral*	*TTS*	*PTS*
Eastern U.S.	107	1	0	3,027	6	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.4.3 Guadalupe Fur Seals (Endangered Species Act-listed)

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Guadalupe fur seals may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-37 and Table 6-38 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Mexico stock (see Table 6-38).

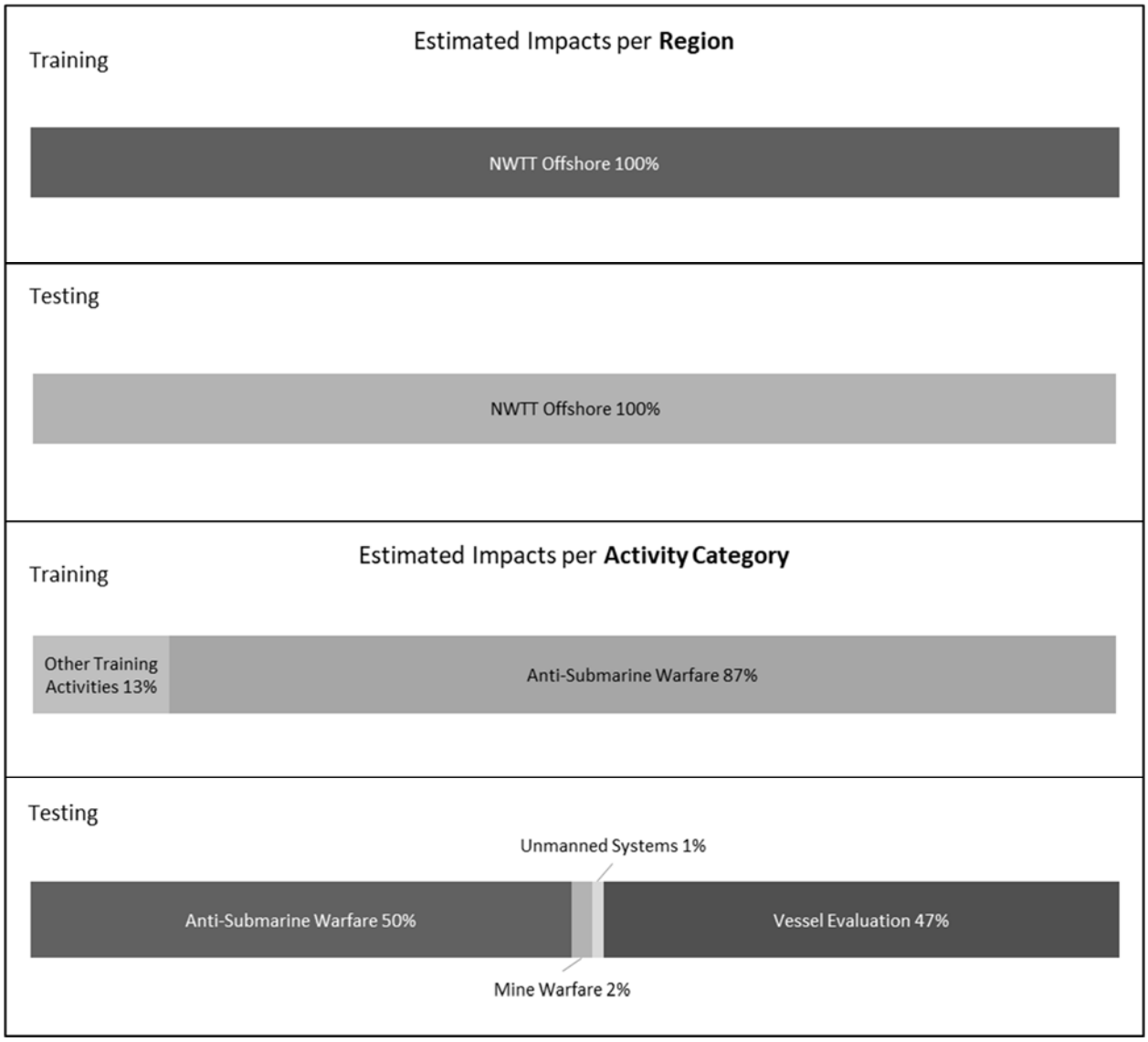
As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of Guadalupe fur seals incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Guadalupe fur seals may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-37 and Table 6-38 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Mexico stock (see Table 6-38).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.
The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of Guadalupe fur seals incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-37: Guadalupe Fur Seal Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-38: Estimated Impacts on Individual Guadalupe Fur Seal Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Mexico	605	3	0	892	10	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.4.4 Northern Fur Seals

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Northern fur seals may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-38 and Table 6-39 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-39).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of northern fur seals incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Northern fur seals may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-38 Table 6-39 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-39).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stocks. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of northern fur seals incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-38: Northern Fur Seal Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-39: Estimated Impacts on Individual Northern Fur Seal Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Eastern Pacific	2,130	4	0	8,424	125	0
California	43	0	0	169	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.4.5 Harbor Seals

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Harbor seals may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under the Proposed Action (see Figure 6-39 and Table 6-40). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-40).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stocks. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of harbor seals incidental to those activities.

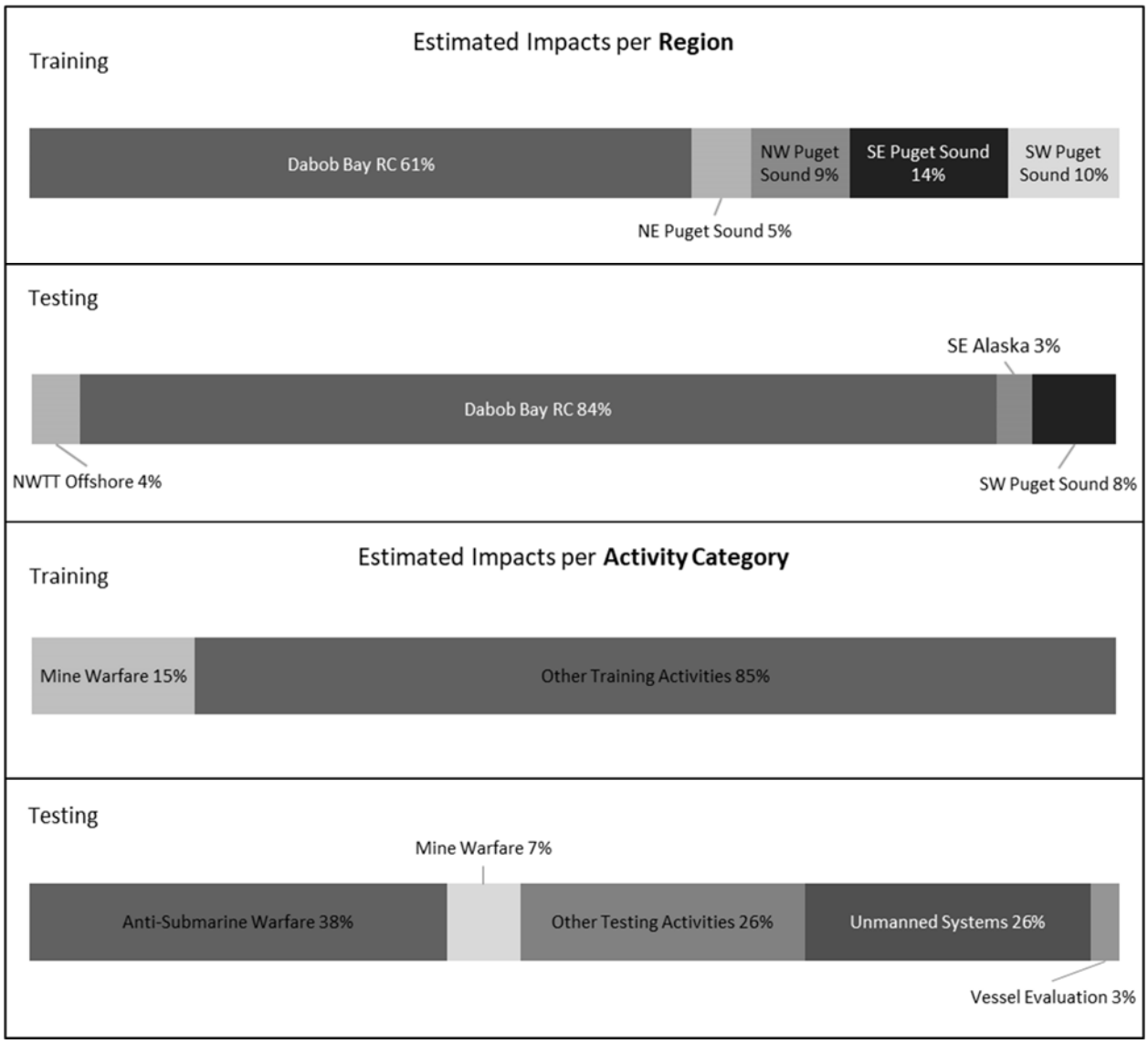
Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Harbor seals may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under the Proposed Action (see Figure 6-39 and Table 6-40 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (see Table 6-40).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to

have any long-term consequences for the species or stocks. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of harbor seals incidental to those activities.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-39: Harbor Seal Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-40: Estimated Impacts on Individual Harbor Seal Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action.

Estimated Impacts by Effect						
Stock	***Training***			***Testing***		
	Behavioral	***TTS***	***PTS***	***Behavioral***	***TTS***	***PTS***
Southeast Alaska - Clarence Strait	0	0	0	2,077	275	0
Oregon/Washington Coastal	0	0	0	1,388	1,766	0
Washington Northern Inland Waters	436	203	0	434	144	0
Hood Canal	2,334	348	0	36,927	23,667	0
Southern Puget Sound	730	360	1	2,544	3,204	3

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.4.6 Northern Elephant Seals

Impacts from Sonar and Other Transducers Under the Proposed Action for Training Activities

Northern elephant seals may be exposed to sounds from sonar and other transducers associated with training activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-40 and Table 6-41 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California stock (see Table 6-41).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during training activities as described under the Proposed Action will result in the unintentional taking of northern elephant seals incidental to those activities.

Impacts from Sonar and Other Transducers Under the Proposed Action for Testing Activities

Northern elephant seals may be exposed to sounds from sonar and other transducers associated with testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under the Proposed Action (see Figure 6-40 and Table 6-41 below). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California stock (see Table 6-41).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of sonar and other transducers during testing activities as described under the Proposed Action will result in the unintentional taking of northern elephant seals incidental to those activities.

Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent.

Figure 6-40: Northern Elephant Seal Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6-41: Estimated Impacts on Individual Northern Elephant Seal Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect						
Stock	*Training*			*Testing*		
	Behavioral	*TTS*	*PTS*	*Behavioral*	*TTS*	*PTS*
California	1,698	209	0	2,437	578	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5 EXPLOSIVE STRESSORS

Assessing whether an explosive detonation may disturb or injure a marine mammal involves understanding the characteristics of the explosive sources, the marine mammals that may be present near the sources, the physiological effects of a close explosive exposure, and the effects of impulsive sound on marine mammal hearing and behavior. Many other factors besides just the received level or pressure wave of an explosion, such as the animal's physical condition and size, prior experience with the explosive sound, and proximity to the explosion may influence physiological effects and behavioral reactions. The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities).

The following Background section discusses what is currently known about explosive effects to marine mammals. North Pacific right whales are considered extralimital or extremely rare and are not likely to be present contemporaneous with Navy training and testing activities in the NWTT Study Area. Therefore, the remainder of the analysis of effects from explosives will not include North Pacific right whales.

6.5.1 BACKGROUND

6.5.1.1 Injury

Injury refers to the direct effects on the tissues or organs of an animal due to exposure to pressure waves. Injury in marine mammals can be caused directly by exposure to explosions. The Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2) provides additional information on injury and the framework used to analyze this potential impact.

6.5.1.1.1 Injury due to Explosives

Explosive injury to marine mammals would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Greaves et al., 1943; Office of the Surgeon 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 (Clark & Ward, 1943). Recoverable injuries would include slight lung injury, such as capillary interstitial bleeding, and contusions to the gastrointestinal tract. More severe injuries, such as tissue lacerations, major hemorrhage, organ rupture, or air in the chest cavity (pneumothorax), would significantly reduce fitness and likely cause death in the wild. Rupture of the lung may also introduce air into the vascular system, producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to critical organs.

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. See Appendix D (Acoustic and Explosive Concepts) for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving explosives occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area has been used for underwater demolitions training for at least three decades without prior known incident. On this occasion, however, a group of approximately 100–150 long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated, which could not be deactivated, on an explosive with a net explosive weight (NEW) of 8.76 pounds (lb.) (3.97 kilograms [kg]) placed at a depth of 48 ft. Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was unsuccessful. 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 & St Leger, 2011). In the Pacific Northwest, there is no known occurrence of mortality or injury to marine mammals due to Navy training or testing events involving explosives.

Relatively little is known about auditory system trauma in marine mammals resulting from explosive exposure, although it is assumed that auditory structures would be vulnerable to blast injuries. Auditory trauma was found in two humpback whales that died following the detonation of a 5,000 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); however, results may not be applicable to the anatomical adaptations for underwater hearing in marine mammals. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue damage distinct from threshold shift or other auditory effects (Section 6.5.1.2, Hearing Loss).

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 principal 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 (Clark & Ward, 1943; Greaves et al., 1943). Results from all of these tests suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

6.5.1.1.1.1 Impulse as a Predictor of Explosive Injury

In the Lovelace studies, acoustic impulse was found to be the metric most related to degree of injury, and the size of an animal's gas-containing cavities was thought to play a role in blast injury susceptibility. The lungs of most marine mammals are similar in proportion to overall body size as those of terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to marine mammals when scaled for body size. Within the marine mammals, mysticetes and deeper divers (e.g., Kogiidae, Physeteridae, Ziphiidae) tend to have lung-to-body-size ratios that are smaller and more similar to terrestrial animal ratios than the shallow diving odontocetes (e.g., Phocoenidae, Delphinidae) and pinnipeds (Fahlman et al., 2014a; Piscitelli et al., 2010). The use of test data with smaller lung-to-body ratios to set injury thresholds may result in a more conservative estimate of potential for damaging effects (i.e., lower thresholds) for animals with larger lung to body ratios.

For these shallow exposures of small terrestrial mammals (masses ranging from 3.4 to 50 kg) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than 6 lb. per square inch per millisecond (psi-ms) (40 pascal seconds [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 marine mammal size and depth in a bubble oscillation model of the lung. Animal depth relates to injury susceptibility in two ways: injury is related to the relative increase in explosive pressure over hydrostatic pressure, and lung collapse with depth reduces the potential for air cavity oscillatory damage. The period over which an impulse must be delivered to cause damage is assumed to be related to the natural oscillation period of an animal's lung, which depends on lung size.

Because gas-containing organs are more vulnerable to primary blast injury, adaptations for diving that allow for collapse of lung tissues with depth may make animals less vulnerable to lung injury with depth. Adaptations for diving include a flexible thoracic cavity, distensible veins that can fill space as air compresses, elastic lung tissue, and resilient tracheas with interlocking cartilaginous rings that provide strength and flexibility (Ridgway, 1972). Older literature suggested complete lung collapse depths at approximately 70 m for dolphins (Ridgway & Howard, 1979) and 20–50 m for phocid seals (Falke et al., 1985; Kooyman et al., 1972). Follow-on work by Kooyman and Sinnett (1982), in which pulmonary shunting was studied in harbor seals and sea lions, suggested that complete lung collapse for these species would be about 170 m and about 180 m, respectively. More recently, evidence in sea lions suggests that complete collapse might not occur until depths as great as 225 m; although the depth of collapse and depth of the dive are related, sea lions can affect the depth of lung collapse by varying the amount of air inhaled on a dive (McDonald & Ponganis, 2012). This is an important consideration for all divers who can modulate lung volume and gas exchange prior to diving via the degree of inhalation and during diving via exhalation (Fahlman et al., 2009); indeed, there are noted differences in pre-dive respiratory behavior, with some marine mammals exhibiting pre-dive exhalation to reduce the lung volume (e.g., phocid seals (Kooyman et al., 1973)).

6.5.1.1.1.2 Peak Pressure as a Predictor of Explosive Injury

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 a stinging sensation on skin, with no enduring effects (Christian & 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.

6.5.1.2 Hearing Loss

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. The Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2) provides additional information on hearing loss and the framework used to analyze this potential impact.

Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. There are no direct measurements of hearing loss in marine mammals due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds, such as those produced by air guns.

6.5.1.2.1 Threshold Shift due to Impulsive Sound Sources

Marine mammal TTS data from impulsive sources are limited to two studies with measured TTS of 6 dB or more: Finneran et al. (2002) reported behaviorally measured TTSs of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun, and Lucke et al. (2009) reported AEP-measured TTS of 7 to 20 dB in a harbor porpoise exposed to single impulses from a seismic air gun.

In addition to these data, Kastelein et al. (2015a) reported behaviorally measured mean TTS of 4 dB at 8 kHz and 2 dB at 4 kHz after a harbor porpoise was exposed to a series of impulsive sounds produced by broadcasting underwater recordings of impact pile driving strikes through underwater sound projectors. The cumulative SEL was approximately 180 dB re 1 μPa^2s. The pressure waveforms for the simulated pile strikes exhibited significant "ringing" not present in the original recordings, and most of the energy in the broadcasts was between 500 and 800 Hz. As a result, some questions exist regarding whether the fatiguing signals were representative of underwater pressure signatures from impact pile driving.

Several impulsive noise exposure studies have also been conducted without behaviorally measurable TTS. Finneran et al. (2000) exposed dolphins and belugas to single impulses from an "explosion simulator," and Finneran et al. (2015) exposed three dolphins to sequences of 10 impulses from a seismic air gun (maximum cumulative SEL = 193 to 195 dB re 1 μPa^2s, peak SPL = 196 to 210 dB re 1 µPa) without measurable TTS. Finneran et al. (2003b) exposed two sea lions to single impulses from an arc-gap transducer with no measurable TTS (maximum unweighted SEL = 163 dB re 1 μPa^2s, peak SPL = 183 dB re 1 µPa).

6.5.1.3 Physiological Stress

Marine mammals naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). The Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2) provides additional information on physiological stress and the framework used to analyze this potential impact.

There are no direct measurements of physiological stress in marine mammals due to exposure to explosive sources. General research findings regarding physiological stress in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 6.4.1.3 (Physiological Stress) above. Because there are many unknowns regarding the occurrence of acoustically induced stress

responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

6.5.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection, discrimination, or recognition of another sound, designated the "signal." The quantitative definition of masking is the amount in decibels an auditory detection, discrimination, or recognition threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in the Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, or changing frequency) and behavioral 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).

There are no direct observations of masking in marine mammals due to exposure to explosive sources. General research findings regarding masking in marine mammals due to exposure to sound are discussed in detail in Masking under Acoustic Stressors (Section 6.4.1.4). Potential masking from explosive sounds is likely to be similar to masking studied for other impulsive sounds such as air guns.

Masking could occur in mysticetes due to the overlap between their low-frequency vocalizations and the dominant frequencies of impulsive sounds; however, masking in odontocetes is less likely unless the activity is in close range where the pulses are more broadband. For example, differential vocal responses in marine mammals were documented in the presence of seismic survey noise. An overall decrease in vocalizations during active surveying was noted in large marine mammal groups (Potter et al., 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio & Clark, 2010), indicative of a possible compensatory response to the increased noise level. Bowhead whales were found to increase call rates in the presence of seismic air gun noise at lower received levels (below 100 dB re 1 μPa^2s cumulative SEL), but once the received level rose above 127 dB re 1 Pa^2s cumulative SEL the call rate began decreasing and stopped altogether once received levels reached 170 dB re 1 Pa^2s cumulative SEL (Blackwell et al., 2015). Nieukirk et al. (2012) recorded both seismic surveys and fin whale 20 Hz calls at various locations around the mid-Atlantic Ocean and hypothesized that distant seismic noise could mask those calls, thereby decreasing the communication range of fin whales, whose vocalizations may propagate over 400 km to reach conspecifics (Spiesberger & Fristrup, 1990). A spotted seal and ringed seal in captivity were exposed to seismic air gun sounds recorded within 1 km and 30 km of an air gun survey conducted in shallow (<40 m) water. They were then tested on their ability to detect a 500-millisecond upsweep centered at 100 Hz at different points in the air gun pulse (start, middle, and end). Based on these results, a 100 Hz vocalization with a source level of 130 dB re 1Pa would not be detected above a seismic survey 1 km away unless the animal was within 1–5 m, and would not be detected above a survey 30 km away beyond 46 m (Sills et al., 2017).

6.5.1.5 Behavioral Reactions

As discussed in Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2), any stimuli in the environment can cause a behavioral response in marine mammals, including noise from explosions. There are few direct observations of behavioral reactions from marine mammals 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. However, the nighttime activity did not seem to be different than that prior to the exercise, and 2 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 10 years in an area where an offshore wind farm was built; these surveys included the periods of preconstruction, construction, and postconstruction. 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 study 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.

Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. However, 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. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns and impact pile driving. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes, odontocetes, and pinnipeds. No data currently exist for sea otters. 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 marine mammals, it is likely that these responses represent a worst-case scenario as compared to responses to explosives used in Navy activities, which would typically consist of single impulses or a cluster of impulses, rather than long-duration, repeated impulses.

6.5.1.5.1 Behavioral Reactions to Impulsive Sound Sources

6.5.1.5.1.1 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., 2003; McCauley et al., 2000; Richardson et al., 1995; Southall et al., 2007). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin, and bowhead whales; it is assumed that these responses are representative of all baleen whale species. The behavioral state of the whale seems to be an integral part of whether or not the animal responds and how they respond, 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, 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and controlled exposure experiments in one Australian study (McCauley et

al., 1998), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al., 2015). However, when comparing received levels and behavioral responses when using ramp-up versus a constant noise level of air guns, 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 air guns, so some of the response was likely due to the presence of the vessel and not the received level of the air guns. 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., 1995), 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., 2003) 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). However, the increase in vessel traffic associated with the surveys and the proximity of the vessels to the whales did effect 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 & 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 (41–45 km) where median received levels were between 116 and 129 dB re 1 µPa, and did not decrease at sites further from the seismic surveys (greater than 104 km) where median 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). Similar patterns were observed for bowhead vocalizations in the presence of tonal sounds associated with drilling activities and were amplified when the presence of both the tonal sounds and air gun pulses (Blackwell et al., 2017).

Mysticetes seem to be the most sensitive taxonomic group of marine mammals 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., explosives fired at a fixed target), and short-term (on the order of hours rather than days or weeks) than were found in these studies and so responses would likely occur in closer proximity or not at all.

6.5.1.5.1.2 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. However, 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 et al., 2015). During construction (including the blasting of old bastions) of a bridge over a waterway commonly used by the Tampa Bay, FL, 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 5−10 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). However, 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) also found strong avoidance responses by harbor porpoises out to 20 km during pile driving; however, all studies found that the animals returned to the area after the cessation of pile driving. When bubble curtains were deployed around pile driving, the avoidance distance appeared to be reduced to half that distance (12 km), and the response only lasted about five hours rather than a day before the animals returned to the area (Dähne et al., 2017). 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, 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. However, 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.

6.5.1.5.1.3 Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995) and Southall et al. (2007). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 µPa and in-air levels of 112 dB re 20 µPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an underwater impulsive source at levels of 165–170 dB re 1 µPa (Finneran et al., 2003b). Harbor and grey seals were also observed to avoid a seismic air gun by rapidly swimming away, and ceased foraging during exposure, but returned to normal behavior afterwards (Thompson et al. 1998, cited in Gordon et al., 2003). In another study, few responses were observed by New Zealand fur seals to a towed air gun array operating at full power; rather, when responses were observed it seemed to be to the physical presence of the vessel and tow apparatus, and these only occurred when the vessel was within 200 m and sometimes as close as 5 m (Lalas & McConnell, 2016). Captive Steller sea lions were exposed to a variety of tonal, sweep, impulsive and broadband sounds to determine what might work as a deterrent from fishing nets. The impulsive sound had a source level of 120 dB re 1 µPa at 1 m, and caused the animals to haul out and refuse to eat fish presented in a net (Akamatsu et al., 1996). Steller sea lions exposed to in-air explosive blasts increased their activity levels and often re-entered the water when hauled out (Demarchi et al., 2012). However, these responses were short-lived and within minutes, the animals had hauled out again, and there were no lasting behavioral impacts in the days following the blasts.

Experimentally, Götz & Janik (2011) tested underwater startle responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's hearing threshold at that frequency]) and a nonstartling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the nonstartling treatment did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal’s response of habituation.

Pinnipeds may be the least sensitive taxonomic group to most noise sources, although some species may be more sensitive than others, and are likely to only respond to loud impulsive sound sources at close ranges by startling, jumping into the water when hauled out, or even cease foraging, but only for brief periods before returning to their previous behavior (e.g., (Southall et al., 2007)). Pinnipeds may even experience TTS (see Section 6.5.1.2, Hearing Loss) before exhibiting a behavioral response (Southall et al., 2007).

6.5.1.6 Stranding

When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a “stranding” (Geraci et al., 1999; Geraci & Lounsbury, 2005; Perrin & Geraci, 2002). Specifically, under U.S. law, a stranding is an event in the wild where: “(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance” (16 U.S.C. section 1421h).

Impulsive sources (e.g., explosions) also have the potential to contribute to strandings, but such occurrences are even less common than those that have been related to certain sonar activities. During a Navy training event on March 4, 2011, at the Silver Strand Training Complex in San Diego, California, three long-beaked common dolphins were killed by an underwater detonation. Further details are provided above. Discussions of mitigation measures associated with these and other training and testing activities are presented in Chapter 11 (Mitigation Measures).

6.5.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking, and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

6.5.2 Impacts from Explosives

Marine mammals could be exposed to energy, sound, and fragments from underwater explosions associated with the proposed activities. Energy from an explosion is capable of causing mortality, injury, hearing loss, a behavioral response, masking, or physiological stress, depending on the level and duration of exposure.

The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries or PTS may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal's abilities, but the individual is likely to recover quickly with little significant effect.

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds, which are within the audible range of most marine mammals, could cause behavioral reactions, masking, and elevated physiological stress. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council 2005). Sounds from explosives could also mask biologically important sounds; however, the duration of individual sounds is very short, reducing the likelihood of substantial auditory masking.

6.5.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be impacted by explosives used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts on marine mammals uses the Navy's Acoustic Effects Model to produce initial estimates of the number of instances that animals that may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures. The steps of this quantitative analysis are described in Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals), which takes into account

- criteria and thresholds used to predict impacts from explosives (see below),
- the density and spatial distribution of marine mammals, and
- 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.

A detailed explanation of this analysis and how the criteria and thresholds were derived is provided in the technical report Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing (U.S. Department of the Navy, 2018b).

6.5.2.1.1 Criteria and Thresholds Used to Estimate Impacts on Marine Mammals from Explosives

6.5.2.1.1.1 Mortality and Injury from Explosives

As discussed above in Section 6.5.1.1 (Injury), two metrics have been identified as predictive of injury: impulse and peak pressure. Peak pressure contributes to the "crack" or "stinging" sensation of a blast wave, compared to the "thump" associated with received impulse. Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 µPa SPL peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects (Christian & Gaspin, 1974).

Because data on explosive injury do not indicate a set threshold for injury, rather a range of risk for explosive exposures, two sets of criteria are provided for use in non-auditory injury assessment. The exposure thresholds are used to estimate the number of animals that may be affected during Navy training and testing activities (see Table 6-42). The thresholds for the farthest range to effect are based on the received level at which 1 percent risk is predicted and are useful for assessing potential effects to marine mammals and level of potential impacts covered by the mitigation zone. 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 impact assessment, marine mammal populations are assumed to be 70 percent adult and 30 percent calf/pup. Sub-adult masses are used to determine onset of effect, in order to estimate the farthest range at which an effect may first be observable. 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)* (U.S. Department of the Navy, 2017b).

Table 6-42: Criteria to Quantitatively Assess Non-Auditory Injury Due to Underwater Explosions

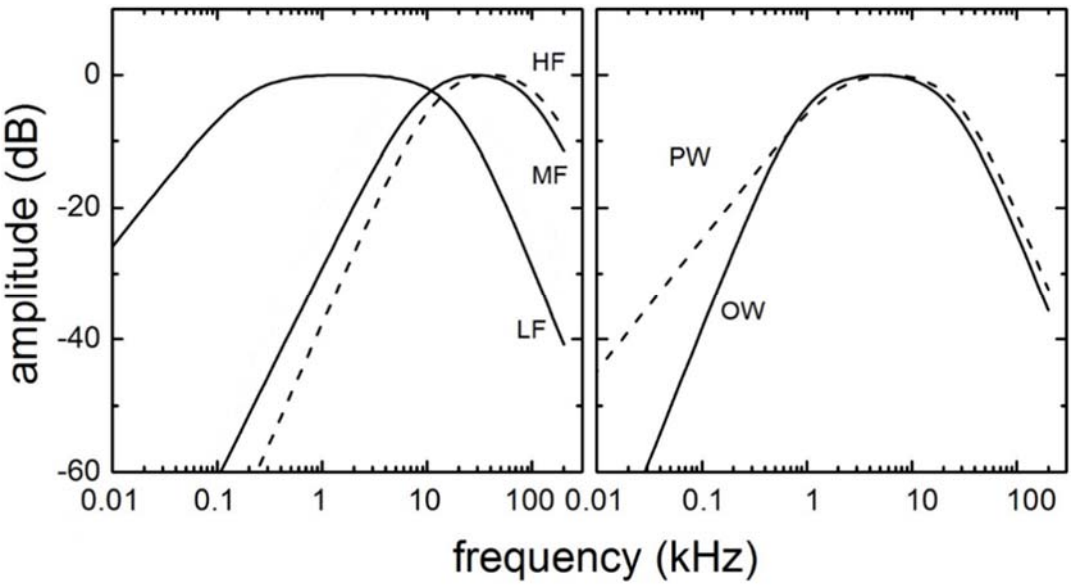
Impact Category	*Exposure Threshold*	*Threshold for Farthest Range to Effect*[2]
Mortality[1]	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s $144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s $144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$
Injury[1]	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ $65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$
	243 dB re 1 µPa SPL peak	237 dB re 1 µPa SPL peak

[1] Impulse delivered over 20% of the estimated lung resonance period. See U.S. Department of the Navy (2017b).
[2] Threshold for one percent risk used to assess mitigation effectiveness. Note: dB re 1 µPa = decibels referenced to 1 micropascal, SPL = sound pressure level, M = animal mass (kg), D = animal depth (m), and Pa-s = Pascal-second

When explosive ordnance (e.g., bomb or missile) detonates, fragments of the weapon are thrown at high-velocity from the detonation point, which can injure or kill marine mammals if they are struck. Risk of fragment injury reduces exponentially with distance as the fragment density is reduced. Fragments underwater tend to be larger than fragments produced by in-air explosions (Swisdak & Montanaro, 1992). Underwater, the friction of the water would quickly slow these fragments to a point where they no longer pose a threat. On the other hand, the blast wave from an explosive detonation moves efficiently through the seawater. Because the ranges to mortality and injury due to exposure to the blast wave are likely to far exceed the zone where fragments could injure or kill an animal, the above thresholds are assumed to encompass risk due to fragmentation.

6.5.2.1.1.2 Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used. Auditory weighting functions are mathematical functions based on a generic band-pass filter that incorporate species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL (Figure 6-41). Due to the band pass nature of auditory weighting functions, they resemble an inverted “U” shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.

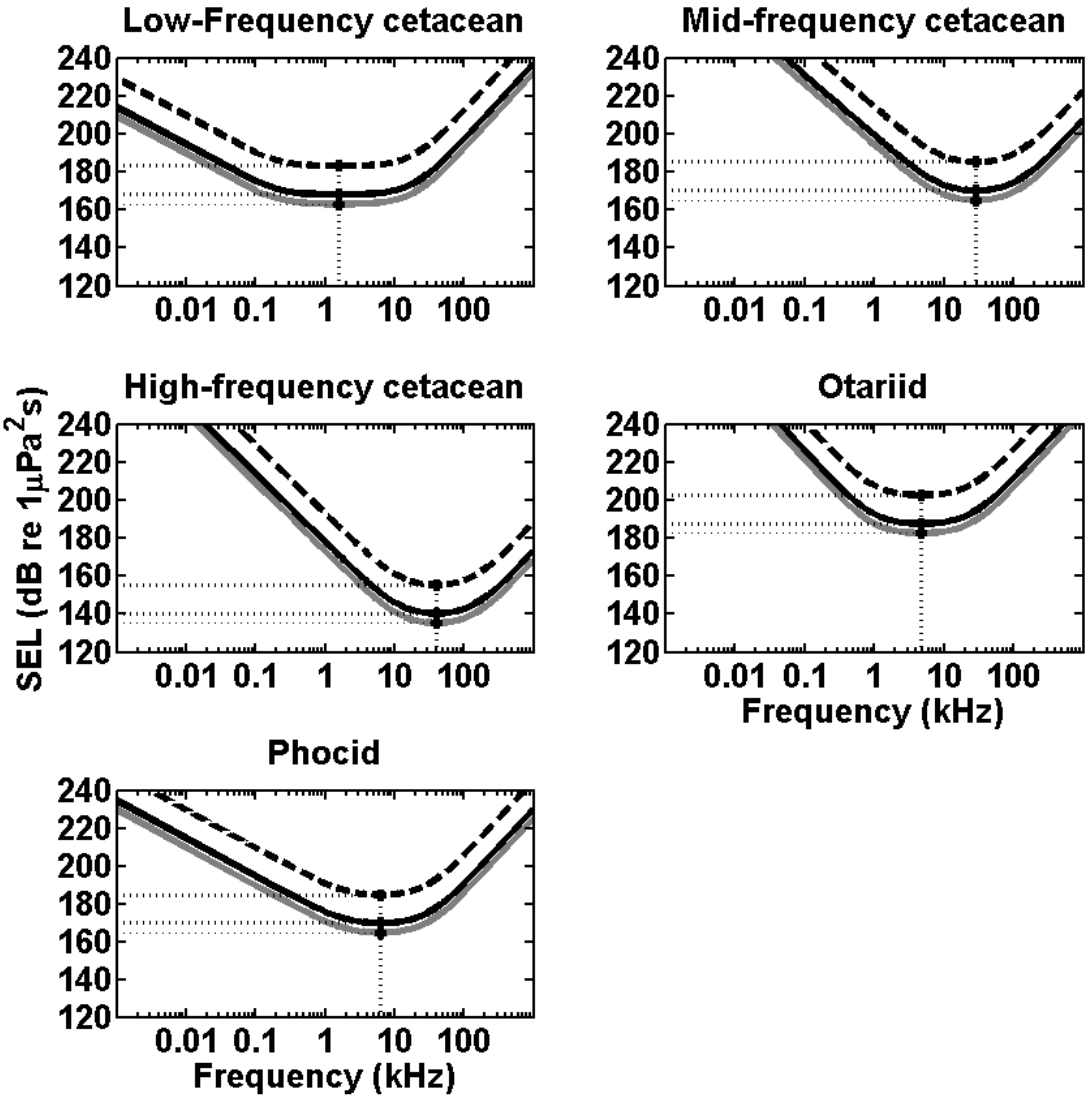


Source: See Finneran (2015) for parameters used to generate the functions and more information on weighting function derivation.
Notes: MF = mid-frequency cetacean, HF = high-frequency cetacean, LF = low-frequency cetacean, PW = phocid (in-water), and OW = otariid (in-water)

Figure 6-41: Navy Phase 3 Weighting Functions for All Species Groups

6.5.2.1.1.3 Hearing Loss from Explosives

Criteria used to define threshold shifts from explosions are derived from the two known studies designed to induce TTS in marine mammals from impulsive sources. Finneran et al. (2002) reported behaviorally measured TTS of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun and Lucke et al. (2009) reported auditory evoked potential-measured TTS of 7–20 dB in a harbor porpoise exposed to single impulses from a seismic air gun. Since marine mammal PTS data from impulsive noise exposures do not exist, onset-PTS levels for all groups were estimated by adding 15 dB to the threshold for non-impulsive sources. This relationship was derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. These frequency dependent thresholds are depicted by the exposure functions for each group's range of best hearing (see Figure 6-42). Weighted sound exposure thresholds for underwater explosive sounds used in the analysis are shown in Table 6-43).



Notes: 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 6-42: Navy Phase III Behavioral, TTS and PTS Exposure Functions for Explosives

Table 6-43: Navy Phase III Weighted Sound Exposure Level Behavioral Response, Temporary Threshold and Permanent Onset Thresholds and Unweighted Peak Sound Pressure Level Temporary Threshold and Permanent Onset Thresholds for Underwater Explosive Sounds

Hearing Group	*Explosive Sound Source*				
	Behavior (SEL) weighted (dB)	*TTS (SEL) weighted (dB)*	*TTS (Peak SPL) unweighted (dB)*	*PTS (SEL) weighted (dB)*	*PTS (Peak SPL) unweighted (dB)*
Low-frequency Cetacean (LF)	*163*	*168*	*213*	*183*	*219*
Mid-frequency Cetacean (MF)	*165*	*170*	*224*	*185*	*230*
High-frequency Cetacean (HF)	*135*	*140*	*196*	*155*	*202*
Otariids in water (OW)	*183*	*188*	*226*	*203*	*232*
Phocid seal in water (PW)	*165*	*170*	*212*	*185*	*218*

Notes: dB = decibels; PTS = permanent threshold shift; SEL = sound exposure level; SPL = sound pressure level; TTS = temporary threshold shift

6.5.2.1.1.4 Behavioral Responses from Explosives

If more than one explosive event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have a behavioral reaction. For exercises with multiple explosions, the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in SEL). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulsive TTS testing (Schlundt et al., 2000).

Some multiple explosive exercises, such as certain naval gunnery exercises, may be treated as a single event because a few explosions occur closely spaced within a very short time (a few seconds). For single explosions at received sound levels below hearing loss thresholds, the most likely behavioral response is a brief alerting or orienting response. Since no further sounds follow the initial brief impulses, significant behavioral reactions would not be expected to occur. This reasoning was applied to previous shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to the criteria used in this analysis.

6.5.2.1.2 Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from explosives, as described in Chapter 11 (Mitigation Measures). Procedural mitigation measures include delaying or ceasing applicable detonations when a marine mammal is observed in a mitigation zone. The mitigation zones for explosives extend beyond the respective average ranges to mortality. Therefore, the impact analysis quantifies the potential for procedural mitigation to reduce the risk of mortality due to exposure to explosives. Two factors are considered when quantifying the effectiveness of procedural mitigation: (1) the extent to which the type of mitigation proposed for an explosive activity (e.g., explosive bombing exercise) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is

determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

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

The ability to observe the ranges to mortality was estimated for each training or testing event. The ability of Navy Lookouts to detect marine mammals within a 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. Certain behaviors, such as leaping and breaching, are visible from a great distance and likely increase sighting distances and detections of those species. Environmental conditions under which the training or testing activity could take place are also considered, such as sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain explosive activities within mitigation areas, as described in Appendix K (Geographic Mitigation Assessment) in the NWTT Draft Supplemental EIS/OEIS. The benefits of mitigation areas are discussed qualitatively and have not been factored into the quantitative analysis process or reductions in take for the MMPA impact estimates. Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. Therefore, mitigation area benefits are discussed in terms of the context of impact avoidance or reduction.

6.5.2.2 Impact Ranges for Explosives

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the explosive criteria and the explosive propagation calculations from the Navy Acoustic Effects Model (Section 6.5.2.1, Methods for Analyzing Impacts from Explosives). The range to effects are shown for a range of explosive bins, from E1 (up to 0.25 lb. net explosive weight) to E11 (greater than 500 lb. to 650 lb. net explosive weight). Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that will cause behavioral response, TTS, PTS, and non-auditory injury. Range to effects is important information in not only predicting impacts from explosives, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that will likely be mitigated within applicable mitigation zones.

Table 6-44 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. Ranges to gastrointestinal tract injury typically exceed ranges to slight lung injury; therefore, the maximum range to effect is not mass-

dependent. Animals within these water volumes 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 6-45.

The following tables (Table 6-46 through Table 6-55) show the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 6.5.2.1.1 (Criteria and Thresholds Used to Estimate Impacts to Marine Mammals from Explosives). Ranges are provided for a representative source depth and cluster size (the number of rounds fired [or buoys dropped] within a very short duration) 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 science; however, data on peak pressure at far distances from explosions are very limited. For additional information on how ranges to impacts from explosions were estimated, see the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing Ranges* (U.S. Department of the Navy, 2018b).

Table 6-44: Ranges[1] to Non-Auditory Injury (in meters) for All Marine Mammal Hearing Groups

Bin	*Range to Non-Auditory Injury (meters)[1]*
E1	12 (11–13)
E2	16 (15–16)
E3	25 (25–45)
E4	31 (23–50)
E5	40 (40–40)
E7	104 (80–190)
E8	149 (130–210)
E10	153 (100–400)
E11	419 (350–725)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses. Modeled ranges based on peak pressure for a single explosion generally exceed the modeled ranges based on impulse (related to animal mass and depth).

Table 6-45: Ranges[1] to Mortality (in meters) for All Marine Mammal Hearing Groups as a Function of Animal Mass

Bin	*Range to Mortality (meters) for Various Animal Mass Intervals (kg)[1]*					
	10 kg	*250 kg*	*1,000 kg*	*5,000 kg*	*25,000 kg*	*72,000 kg*
E1	3 (2–3)	1 (0–3)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
E2	4 (3–5)	2 (1–3)	1 (0–1)	0 (0–0)	0 (0–0)	0 (0–0)
E3	10 (9–20)	5 (3–20)	2 (1–5)	0 (0–3)	0 (0–1)	0 (0–1)
E4	13 (11–19)	7 (4–13)	3 (2–4)	2 (1–3)	1 (1–1)	1 (0–1)
E5	13 (11–15)	7 (4–11)	3 (3–4)	2 (1–3)	1 (1–1)	1 (0–1)
E7	49 (40–80)	27 (15–60)	13 (10–20)	9 (5–12)	4 (4–6)	3 (2–4)
E8	65 (60–75)	34 (22–55)	17 (14–20)	11 (9–13)	6 (5–6)	5 (4–5)
E10	43 (40–50)	25 (16–40)	13 (11–16)	9 (7–11)	5 (4–6)	4 (3–4)
E11	185 (90–230)	90 (30–170)	40 (30–50)	28 (23–30)	15 (13–16)	11 (9–13)

[1]Average distance to mortality (meters) is depicted above the minimum and maximum distances, which are in parentheses for each animal mass interval.
Notes: kg = kilogram

Table 6-46: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for High-Frequency Cetaceans

Range to Effects for Explosives: High-Frequency Cetaceans[1]					
Range to TTS (meters)	*Range to TTS (meters)*	*Range to TTS (meters)*	*Range to TTS (meters)*	*Range to TTS (meters)*	*Range to TTS (meters)*
E1	0.1	1	361 (350–370)	1,108 (1,000–1,275)	1,515 (1,025–2,025)
		18	1,002 (925–1,025)	2,404 (1,275–4,025)	3,053 (1,275–5,025)
E2	0.1	1	439 (420–450)	1,280 (1,025–1,775)	1,729 (1,025–2,525)
		5	826 (775–875)	1,953 (1,275–3,025)	2,560 (1,275–4,275)

Table 6-46: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for High-Frequency Cetaceans (continued)

Range to Effects for Explosives: High-frequency cetaceans[1]					
Bin	***Source Depth (m)***	***Cluster Size***	***Range to PTS (m)***	***Range to TTS (m)***	***Range to Behavioral (m)***
E3	10	1	1,647 (160–3,525)	2,942 (160–10,275)	3,232 (160–12,275)
		12	3,140 (160–9,525)	3,804 (160–17,525)	3,944 (160–21,775)
	18.25	1	684 (550–1,000)	2,583 (1,025–5,025)	4,217 (1,525–7,525)
		12	1,774 (1,025–3,775)	5,643 (1,775–10,025)	7,220 (2,025–13,275)
E4	10	2	1,390 (950–3,025)	5,250 (2,275–8,275)	7,004 (2,775–11,275)
	30	2	1,437 (925–2,775)	4,481 (1,525–7,775)	5,872 (2,775–10,525)
	70	2	1,304 (925–2,275)	3,845 (2,525–7,775)	5,272 (3,525–9,525)
	90	2	1,534 (900–2,525)	5,115 (2,525–7,525)	6,840 (3,275–10,275)
E5	0.1	1	940 (850–1,025)	2,159 (1,275–3,275)	2,762 (1,275–4,275)
		20	1,930 (1,275–2,775)	4,281 (1,775–6,525)	5,176 (2,025–7,775)
E7	10	1	2,536 (1,275–3,775)	6,817 (2,775–11,025)	8,963 (3,525–14,275)
	30	1	1,916 (1,025–4,275)	5,784 (2,775–10,525)	7,346 (2,775–12,025)
E8	45.75	1	1,938 (1,275–4,025)	4,919 (1,775–11,275)	5,965 (2,025–15,525)
E10	0.1	1	1,829 (1,025–2,775)	4,166 (1,775–6,025)	5,023 (2,025–7,525)
E11	91.4	1	3,245 (2,025–6,775)	6,459 (2,525–15,275)	7,632 (2,775–19,025)
	200	1	3,745 (3,025–5,025)	7,116 (4,275–11,275)	8,727 (5,025–15,025)

[1] Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances (due to varying propagation environments), which are in parentheses.
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 6-47: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for High-Frequency Cetaceans

Range to Effects for Explosives: High-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	713 (625–800)	1,018 (775–1,275)
E2	0.1	833 (700–1,000)	1,151 (850–1,525)
E3	10	2,229 (160–6,025)	2,994 (160–9,775)
	18.25	2,030 (1,275–5,775)	2,982 (1,275–6,775)
E4	10	2,990 (1,275–5,775)	5,338 (2,275–10,025)
	30	2,321 (1,525–4,025)	4,064 (2,275–7,525)
	70	3,100 (1,775–4,525)	4,731 (3,525–6,525)
	90	3,046 (2,025–4,525)	4,850 (2,775–8,275)
E5	0.1	1,508 (1,000–2,275)	2,078 (1,025–3,525)
E7	10	6,747 (3,275–12,025)	10,248 (4,275–20,525)
	30	6,159 (3,025–9,275)	10,175 (4,775–17,275)
E8	45.75	4,661 (1,775–18,775)	10,961 (1,775–47,025)
E10	0.1	2,880 (1,275–4,775)	3,807 (1,775–12,775)
E11	91.4	16,639 (2,525–49,275)	39,992 (6,525–97,775)
	200	13,555 (4,275–42,775)	45,123 (39,525–88,775)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 6-48: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Low-Frequency Cetaceans

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	52 (50–55)	221 (120–250)	354 (160–420)
		18	177 (110–200)	656 (230–875)	836 (280–1,025)
E2	0.1	1	66 (55–70)	276 (140–320)	432 (180–525)
		5	128 (90–140)	512 (200–650)	735 (250–975)
E3	10	1	330 (160–550)	1,583 (160–4,025)	2,085 (160–7,525)
		12	1,177 (160–2,775)	2,546 (160–11,775)	2,954 (160–17,025)
	18.25	1	198 (180–220)	1,019 (490–2,275)	1,715 (625–4,025)
		12	646 (390–1,025)	3,723 (800–9,025)	6,399 (1,025–46,525)
E4	10	2	462 (400–600)	3,743 (2,025–7,025)	6,292 (2,525–13,275)
	30	2	527 (330–950)	3,253 (1,775–4,775)	5,540 (2,275–8,275)
	70	2	490 (380–775)	3,026 (1,525–4,775)	5,274 (2,275–7,775)
	90	2	401 (360–500)	3,041 (1,275–4,525)	5,399 (1,775–9,275)
E5	0.1	1	174 (100–260)	633 (220–850)	865 (270–1,275)
		20	550 (200–700)	1,352 (420–2,275)	2,036 (700–4,275)
E7	10	1	1,375 (875–2,525)	7,724 (3,025–15,025)	11,787 (4,525–25,275)
	30	1	1,334 (675–2,025)	7,258 (2,775–11,025)	11,644 (4,525–24,275)
E8	45.75	1	1,227 (575–2,525)	3,921 (1,025–17,275)	7,961 (1,275–48,525)
E10	0.1	1	546 (200–700)	1,522 (440–5,275)	3,234 (850–30,525)
E11	91.4	1	2,537 (950–5,525)	11,249 (1,775–50,775)	37,926 (6,025–94,775)
	200	1	2,541 (1,525–4,775)	7,407 (2,275–43,275)	42,916 (6,275–51,275)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 6-49: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Low-Frequency Cetaceans

Range to Effects for Explosives: Low-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	133 (90–150)	234 (110–270)
E2	0.1	165 (100–180)	288 (120–340)
E3	10	450 (160–1,000)	907 (160–3,275)
	18.25	355 (260–825)	664 (390–1,775)
E4	10	402 (370–430)	833 (650–1,275)
	30	582 (300–975)	938 (470–2,025)
	70	571 (370–1,275)	891 (550–1,775)
	90	437 (370–750)	933 (650–1,525)
E5	0.1	410 (150–500)	683 (210–900)
E7	10	1,121 (750–2,025)	2,248 (1,025–4,775)
	30	1,307 (525–2,275)	1,829 (775–3,775)
E8	45.75	1,486 (575–3,525)	2,130 (800–5,775)
E10	0.1	925 (280–1,275)	1,243 (350–1,775)
E11	91.4	2,845 (950–7,525)	3,662 (1,025–9,025)
	200	3,284 (1,525–6,025)	4,586 (1,775–8,275)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 6-50: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Mid-Frequency Cetaceans

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)	118 (110–120)	203 (190–210)
		18	96 (90–100)	430 (410–440)	676 (600–700)
E2	0.1	1	30 (30–30)	146 (140–150)	246 (230–250)
		5	64 (60–65)	298 (290–300)	493 (470–500)
E3	10	1	61 (50–100)	512 (160–750)	928 (160–2,025)
		12	300 (160–625)	1,604 (160–3,525)	2,085 (160–5,525)
	18.25	1	40 (35–40)	199 (180–280)	368 (310–800)
		12	127 (120–130)	709 (575–1,000)	1,122 (875–2,525)
E4	10	2	73 (70–75)	445 (400–575)	765 (600–1,275)
	30	2	71 (65–90)	554 (320–1,025)	850 (525–1,775)
	70	2	63 (60–85)	382 (320–675)	815 (525–1,275)
	90	2	59 (55–85)	411 (310–900)	870 (525–1,275)
E5	0.1	1	79 (75–80)	360 (350–370)	575 (525–600)
		20	295 (280–300)	979 (800–1,275)	1,442 (925–1,775)
E7	10	1	121 (110–130)	742 (575–1,275)	1,272 (875–2,275)
	30	1	111 (100–130)	826 (500–1,775)	1,327 (925–2,275)
E8	45.75	1	133 (120–170)	817 (575–1,525)	1,298 (925–2,525)
E10	0.1	1	273 (260–280)	956 (775–1,025)	1,370 (900–1,775)
E11	91.4	1	242 (220–310)	1,547 (1,025–3,025)	2,387 (1,275–4,025)
	200	1	209 (200–300)	1,424 (1,025–2,025)	2,354 (1,525–3,775)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Note: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 6-51: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Mid-Frequency Cetaceans

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	44 (40–45)	86 (80–90)
E2	0.1	59 (55–60)	106 (100–110)
E3	10	122 (100–230)	245 (160–410)
	18.25	100 (100–100)	190 (180–280)
E4	10	120 (120–120)	247 (240–260)
	30	136 (120–220)	365 (230–750)
	70	129 (120–200)	257 (230–440)
	90	126 (120–190)	247 (230–380)
E5	0.1	160 (150–170)	295 (280–300)
E7	10	309 (300–370)	592 (525–825)
	30	483 (290–850)	840 (525–1,775)
E8	45.75	561 (350–1,025)	1,056 (625–2,275)
E10	0.1	557 (490–600)	878 (625–1,025)
E11	91.4	1,187 (650–2,525)	2,272 (1,025–4,275)
	200	683 (650–950)	1,972 (1,025–4,025)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 6-52: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Otariids

Range to Effects for Explosives: Otariids[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	**Range to *PTS* (meters)**	**Range to *TTS* (meters)**	**Range to *Behavioral* (meters)**
E1	0.1	1	7 (7–8)	34 (30–35)	58 (55–60)
		18	25 (25–25)	124 (120–130)	208 (200–210)
E2	0.1	1	9 (9–10)	43 (40–45)	72 (70–75)
		5	19 (19–20)	88 (85–90)	145 (140–150)
E3	10	1	21 (18–25)	135 (120–210)	250 (160–370)
		12	82 (75–100)	551 (160–875)	954 (160–2,025)
	18.25	1	15 (15–15)	91 (85–95)	155 (150–160)
		12	53 (50–55)	293 (260–430)	528 (420–825)
E4	10	2	30 (30–30)	175 (170–180)	312 (300–350)
	30	2	25 (25–25)	176 (160–250)	400 (290–750)
	70	2	26 (25–35)	148 (140–200)	291 (250–400)
	90	2	26 (25–35)	139 (130–190)	271 (250–360)
E5	0.1	1	25 (24–25)	111 (110–120)	188 (180–190)
		20	93 (90–95)	421 (390–440)	629 (550–725)
E7	10	1	60 (60–60)	318 (300–360)	575 (500–775)
	30	1	53 (50–65)	376 (290–700)	742 (500–1,025)
E8	45.75	1	55 (55–55)	387 (310–750)	763 (525–1,275)
E10	0.1	1	87 (85–90)	397 (370–410)	599 (525–675)
E11	91.4	1	100 (100–100)	775 (550–1,275)	1,531 (900–3,025)
	200	1	94 (90–100)	554 (525–700)	1,146 (900–1,525)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 6-53: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Otariids

Range to Effects for Explosives: Otariids[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	37 (35–40)	69 (65–70)
E2	0.1	48 (45–50)	88 (80–90)
E3	10	99 (85–170)	197 (150–370)
	18.25	80 (80–85)	154 (150–200)
E4	10	100 (100–100)	190 (190–190)
	30	105 (100–140)	262 (190–675)
	70	106 (100–160)	206 (190–350)
	90	103 (100–150)	197 (190–320)
E5	0.1	128 (120–130)	243 (230–250)
E7	10	255 (250–260)	471 (440–500)
	30	419 (240–1,025)	722 (440–1,025)
E8	45.75	434 (280–975)	913 (525–2,025)
E10	0.1	476 (450–490)	739 (600–875)
E11	91.4	934 (525–1,775)	1,912 (1,000–3,775)
	200	553 (525–800)	1,516 (1,000–3,525)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 6-54: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Phocids

Range to Effects for Explosives: Phocids[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E1	0.1	1	47 (45–50)	219 (210–230)	366 (350–370)
		18	171 (160–180)	764 (725–800)	1,088 (1,025–1,275)
E2	0.1	1	59 (55–60)	273 (260–280)	454 (440–460)
		5	118 (110–120)	547 (525–550)	881 (825–925)
E3	10	1	185 (160–260)	1,144 (160–2,775)	1,655 (160–4,525)
		12	760 (160–1,525)	2,262 (160–8,025)	2,708 (160–12,025)
	18.25	1	112 (110–120)	628 (500–950)	1,138 (875–2,525)
		12	389 (330–625)	2,248 (1,275–4,275)	4,630 (1,275–8,525)
E4	10	2	226 (220–240)	1,622 (950–3,275)	3,087 (1,775–5,775)
	30	2	276 (200–600)	1,451 (1,025–2,275)	2,611 (1,775–4,275)
	70	2	201 (180–280)	1,331 (1,025–1,775)	2,403 (1,525–3,525)
	90	2	188 (170–270)	1,389 (975–2,025)	2,617 (1,775–3,775)
E5	0.1	1	151 (140–160)	685 (650–700)	1,002 (950–1,025)
		20	563 (550–575)	1,838 (1,275–2,275)	2,588 (1,525–3,525)
E7	10	1	405 (370–490)	3,185 (1,775–6,025)	5,314 (2,275–11,025)
	30	1	517 (370–875)	2,740 (1,775–4,275)	4,685 (3,025–7,275)
E8	45.75	1	523 (390–1,025)	2,502 (1,525–6,025)	3,879 (2,025–10,275)
E10	0.1	1	522 (500–525)	1,800 (1,275–2,275)	2,470 (1,525–3,275)
E11	91.4	1	1,063 (675–2,275)	5,043 (2,775–10,525)	7,371 (3,275–18,025)
	200	1	734 (675–850)	5,266 (3,525–9,025)	7,344 (5,025–12,775)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 6-55: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Phocids

Range to Effects for Explosives: Phocids[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	156 (140–160)	291 (270–300)
E2	0.1	198 (190–200)	366 (350–370)
E3	10	582 (160–1,775)	975 (160–2,525)
	18.25	398 (330–700)	795 (600–1,775)
E4	10	456 (430–490)	940 (750–1,775)
	30	700 (430–1,025)	1,111 (825–2,025)
	70	645 (420–1,275)	1,085 (750–1,775)
	90	557 (420–875)	1,082 (750–1,775)
E5	0.1	538 (525–550)	936 (850–1,000)
E7	10	1,241 (875–2,025)	2,571 (1,275–5,775)
	30	1,495 (900–2,275)	2,185 (1,275–3,775)
E8	45.75	1,919 (1,025–4,025)	3,206 (1,775–7,275)
E10	0.1	1,469 (1,025–1,775)	2,244 (1,275–3,025)
E11	91.4	4,277 (2,525–9,275)	6,965 (3,025–13,775)
	200	4,388 (2,775–7,025)	6,853 (4,275–12,775)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

6.5.2.3 Impacts from Explosives Stressors Under the Proposed Action

The following provides a brief description of training and testing as it pertains to underwater and near-surface explosions under the Proposed Action:

As described in Section 1.5 (Proposed Action), Table 1-3, and Table 1-7, training activities under the Proposed Action would use underwater detonations and explosive ordnance. Within the Proposed Action, most training activities that use explosives reoccur on an annual basis, with some year-to-year variability. Training activities involving explosives would be concentrated in the NWTT Offshore Area. Detonations would generally occur greater than 50 NM from shore, with the exception of a very small

amount of mine neutralization training activities that would occur in existing mine warfare areas in Inland Waters (i.e., Crescent Harbor and Hood Canal Explosive Ordinance Disposal Training Ranges).

As described in Table 1-4 and Table 1-8, testing activities under the Proposed Action would use underwater detonations and explosive ordnance. Within the Proposed Action, most testing activities that use explosives reoccur on an annual basis. All testing involving explosives will occur in the Offshore Area, and with the exception of mine countermeasure and neutralization testing (new testing activities in Phase III), will occur at distances greater than 50 NM from shore. This new activity would occur closer to shore than other activities analyzed in the 2015 NWTT Final EIS/OEIS that involved the use of in-water explosives in the Offshore Area. Although this activity would occur closer to shore, it would typically occur in water depths greater than 100 feet.

6.5.2.3.1 Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from explosives (see above Section 6.5.2.1, Methods for Analyzing Impacts from Explosives) are discussed below. The numbers of potential impacts estimated for individual species of marine mammals from exposure to explosive energy and sound for training activities under the Proposed Action are shown in Chapter 5 (Type of Incidental Taking Authorization Requested). Additionally, estimated numbers of potential impacts from the quantitative analysis for each species are presented below (e.g., Figure 6-43). The most likely regions and activity categories from which the impacts could occur are displayed in the impact graphics for each species. There is a potential for impacts to occur anywhere within the Study Area where sound and energy from explosives and the species overlap, although only regions or activity categories where 0.5 percent of the impacts, or greater, are estimated to occur are graphically represented in the impact graphics below. All (i.e., grand total) estimated impacts are also included, regardless of region or category.

Regions within the NWTT Study Area include (see Study Area maps in Chapter 2) NWTT Offshore, Dabob Bay Range Complex, Northeast Puget Sound, Southwest Puget Sound, and Southeast Alaska.

The numbers of activities planned under the Proposed Action can vary slightly from year-to-year. The Proposed Action results are presented for a maximum explosive use year; however, during most years, explosive use would be less, resulting in fewer potential impacts.

6.5.2.3.2 Mysticetes

Mysticetes may be exposed to sound and energy from explosions associated with training and testing activities throughout the year. Explosions produce sounds that are within the hearing range of mysticetes (see Section 6.3, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking, and hearing loss. The quantitative analysis estimates TTS and PTS in mysticetes. Impact ranges for mysticetes exposed to explosive sound and energy are discussed under low-frequency cetaceans in Section 6.5.2.2 (Impact Ranges for Explosives).

Mysticetes that do experience threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from threshold shift begins almost immediately after the noise exposure ceases and can take a few minutes to a few days, depending on the severity of the initial shift, to recover. TTS would recover fully, and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies

equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the short period that a mysticete had TTS, or permanently for PTS, social calls from conspecifics could be more difficult to detect or interpret, the ability to detect predators may be reduced, and the ability to detect and avoid sounds from approaching vessels or other stressors might be reduced. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether a TTS would affect a mysticete's ability to locate prey or rate of feeding.

Research and observations of auditory masking in marine mammals due to impulsive sounds are discussed in Section 6.5.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in mysticetes that are nearby, although sounds from explosions last for only a few seconds at most. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations, such as some naval gunfire exercises, could create some masking for mysticetes in the area over the short duration of the event. Potential costs to mysticetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water; the effect is over the moment the sound has ceased.

Research and observations (see Section 6.5.2.1.1.4, Behavioral Responses from Explosives) show that if mysticetes are exposed to impulsive sounds such as those from explosives, they may react in a variety of ways, which may include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, changing vocalization, or showing no response at all. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short term and intermittent, and because detonations usually occur within a small area, behavioral reactions from mysticetes are likely to be short term and low to moderate severity, although there are no estimated behavioral impacts to mysticetes.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 6.5.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

6.5.2.3.2.1 North Pacific Right Whales (Endangered Species Act-Listed)

North Pacific right whales are extremely rare in the Study Area. Data on right whale presence is insufficient to develop density estimates for use in the Navy Acoustic Effects Model for estimating the number of animals that may be exposed to explosives. Based on the highly unlikely presence of North Pacific right whales in the offshore portion of the Study Area and no records of occurrence in the Inland Waters or Behm Canal portions of the Study Area, in addition to the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), exposure of any North Pacific right whales to explosives associated with training activities is highly unlikely.

Impacts from Explosives Under the Proposed Action for Training Activities

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of North Pacific right whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of North Pacific right whales.

6.5.2.3.2.2 Blue Whales (Endangered Species Act-Listed)

Impacts from Explosives Under the Proposed Action for Training Activities

Blue whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under the Proposed Action, estimates no impacts for training activities (see Table 6-56Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

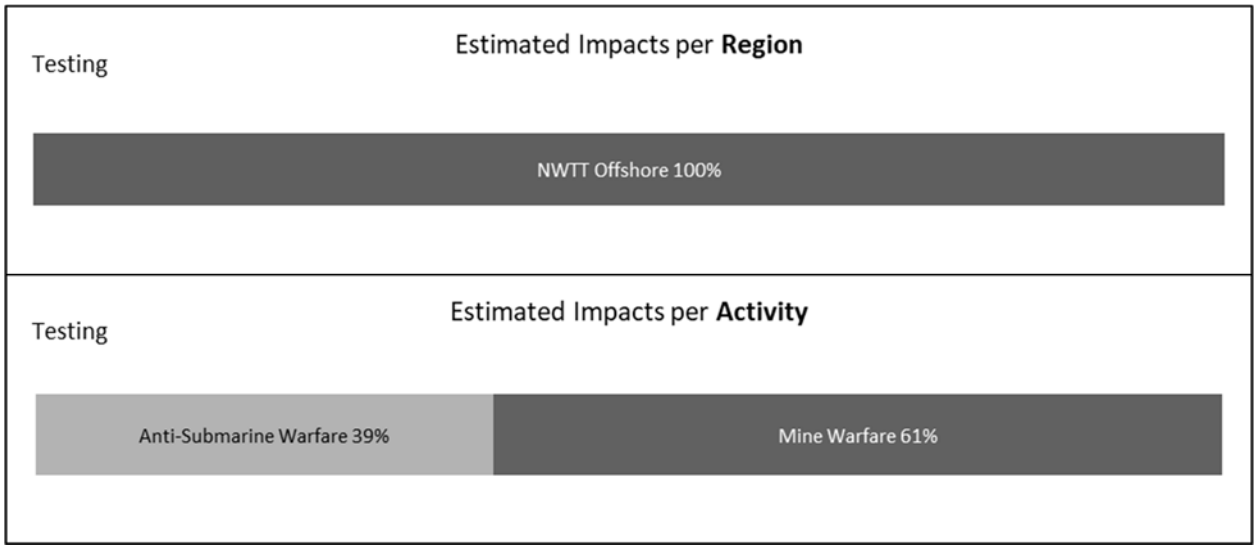
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of blue whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Blue whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under the Proposed Action, estimates behavioral reactions (see Figure 6-43 and Table 6-56 below). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Eastern North Pacific stock (see Table 6-56).

As described for mysticetes above, even a few minor to moderate behavioral impacts to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of blue whales incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-43: Blue Whale Impacts Estimated per Year from the Maximum Number of Explosions During Testing Under the Proposed Action

Table 6-56: Estimated Impacts on Individual Blue Whale Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
Eastern North Pacific	0	0	0	0	1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.3 Fin Whales (Endangered Species Act-Listed)

Impacts from Explosives Under the Proposed Action for Training Activities

Fin whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities (see Table 6-57). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

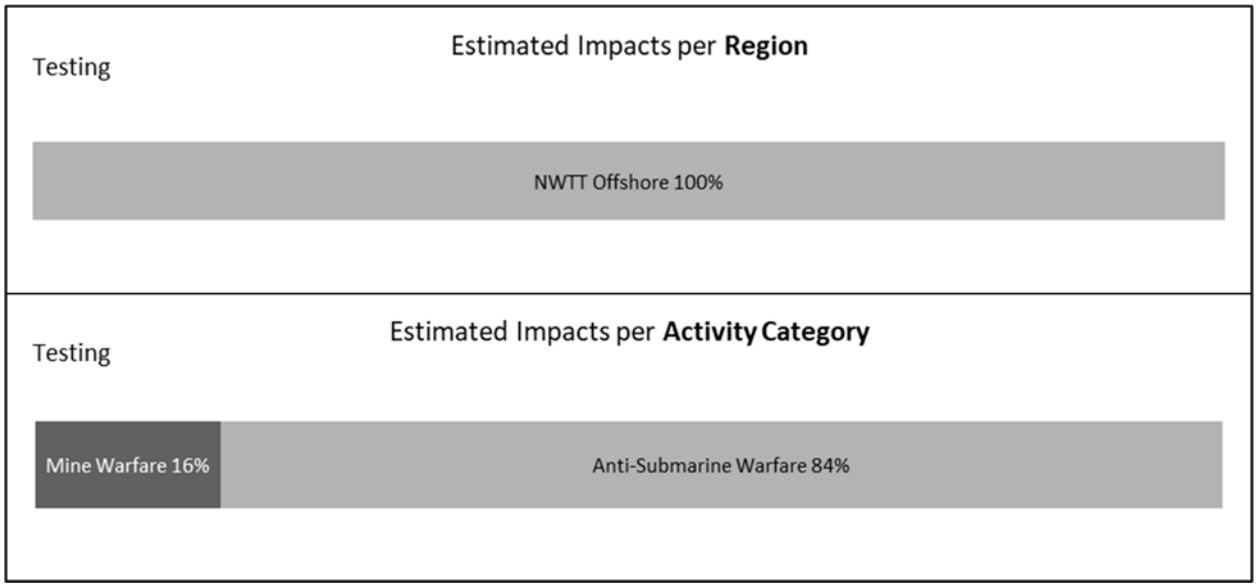
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of fin whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Fin whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions and TTS (see Figure 6-44 andTable 6-57). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to California, Oregon, and Washington stock (see Table 6-57).

As described for mysticetes above, even a few minor to moderate behavioral responses or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of fin whales incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-44: Fin Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-57: Estimated Impacts on Individual Fin Whale Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
California, Oregon, & Washington	0	0	0	0	6	2	0	0
Northeast Pacific	0	0	0	0	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.4 Sei Whales (Endangered Species Act-Listed)

Impacts from Explosives Under the Proposed Action for Training Activities

Sei whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities (see Table 6-58 and tabular results in Section 5.1, Incidental Take Request from Acoustic and Explosive Sources). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

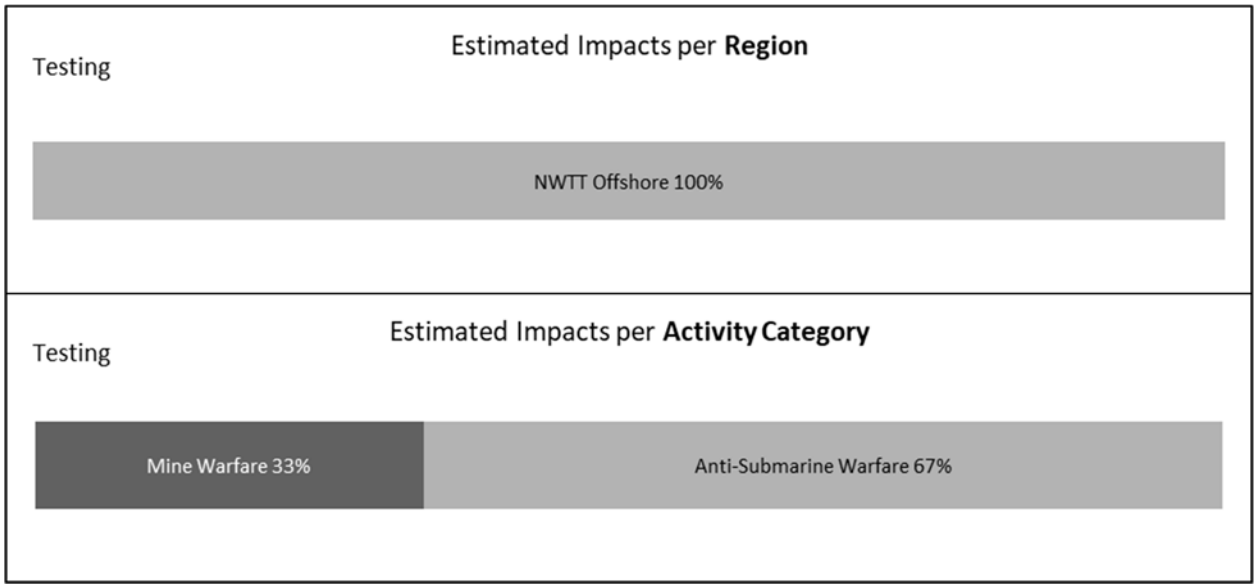
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of sei whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Sei whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions and TTS (see Figure 6-45 and Table 6-58 below). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Eastern North Pacific stock (see Table 6-58).

As described for mysticetes above, even a few minor to moderate behavioral responses or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of sei whales incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-45: Sei Whale Impacts Estimated per Year from the Maximum Number of Explosions During Testing Under the Proposed Action

Table 6-58: Estimated Impacts on Individual Sei Whale Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
Eastern North Pacific	0	0	0	0	1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.5 Minke Whales

Impacts from Explosives Under the Proposed Action for Training Activities

Minke whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities (see Table 6-59). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

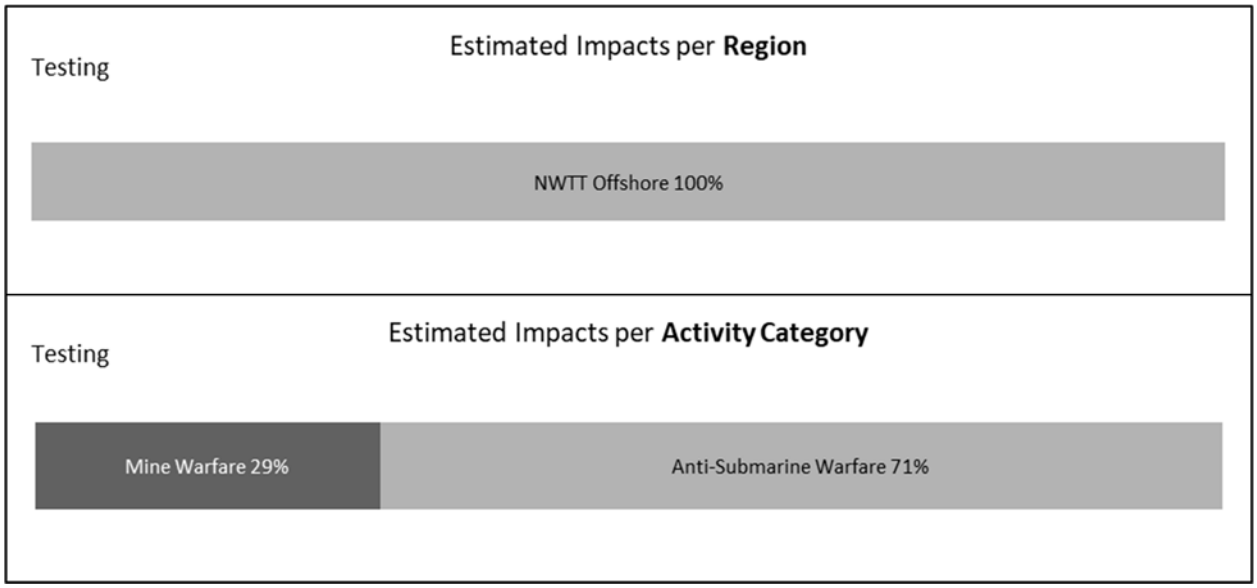
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of minke whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Minke whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions and TTS (see Figure 6-46 and Table 6-59 below). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-59).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of minke whales incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-46: Minke Whale Impacts Estimated per Year from the Maximum Number of Explosions During Testing Under the Proposed Action

Table 6-59: Estimated Impacts on Individual Minke Whale Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	*Training*				*Testing*			
	Behavioral	*TTS*	*PTS*	*Injury*	*Behavioral*	*TTS*	*PTS*	*Injury*
Alaska	0	0	0	0	0	0	0	0
California, Oregon, & Washington	0	0	0	0	4	2	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.6 Humpback Whales (some DPSs are Endangered Species Act-Listed)

Impacts have been modeled for the Hawaii (Central North Pacific stock) population of humpback whales, which are not ESA listed, and for the Mexico (California, Oregon, and Washington stock) and Central America (California, Oregon, and Washington) stock populations of humpback whales, which are ESA listed. Western North Pacific DPS/stock humpback whales are not likely to be present in the NWTT Study Area during or in proximity to any of the proposed training or testing activities.

Impacts from Explosives Under the Proposed Action for Training Activities

Humpback whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities (see Table 6-60). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of humpback whales.

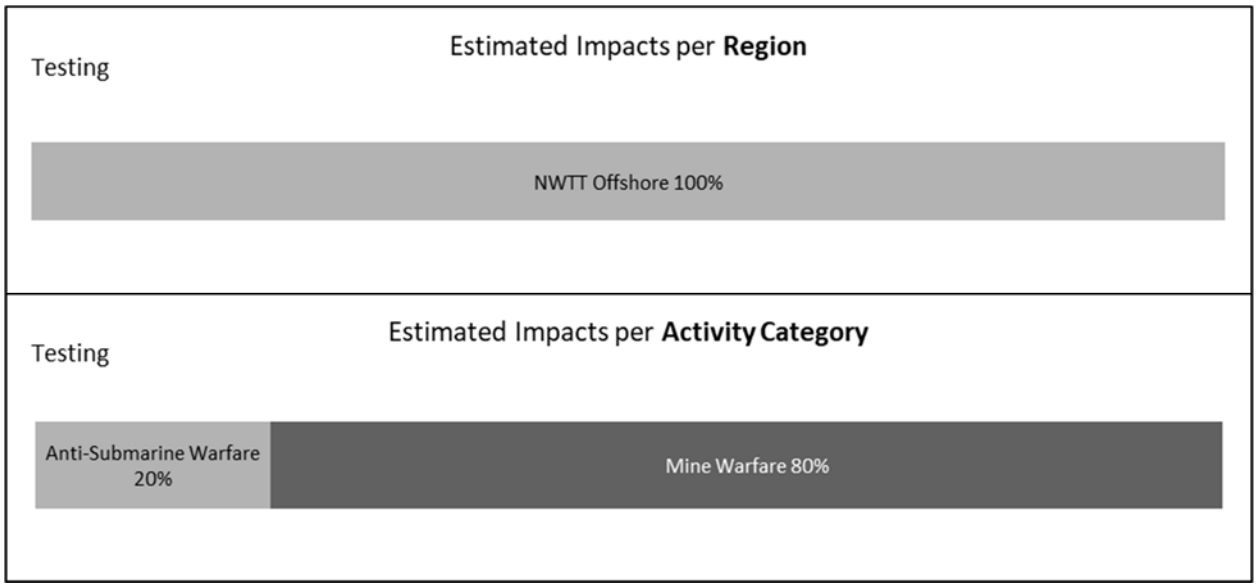
Impacts from Explosives Under the Proposed Action for Testing Activities

Humpback whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions and TTS (see Figure 6-47 and Table 6-60 below). Impact ranges for this species are discussed in Section 6.5.2.2, Impact Ranges for Explosives. Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-60).

As described for mysticetes above, even a few minor to moderate behavioral impacts or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented

as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of humpback whales incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-47: Humpback Whale Impacts Estimated per Year from the Maximum Number of Explosions During Testing Under the Proposed Action

Table 6-60: Estimated Impacts on Individual Humpback Whale Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
California, Oregon, & Washington	0	0	0	0	1	1	0	0
Central North Pacific	0	0	0	0	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.7 Gray Whales (one DPS is Endangered Species Act-Listed)

The vast majority of gray whales in the study are from the non-endangered Eastern North Pacific stock, and all of the modeled impacts are attributed to this stock. On rare occasions Western North Pacific gray whales, which are Endangered Species Act-Listed, occur in the Study Area but are not included in this analysis.

Impacts from Explosives Under the Proposed Action for Training Activities

Gray whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities (see Table 6-61 below). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

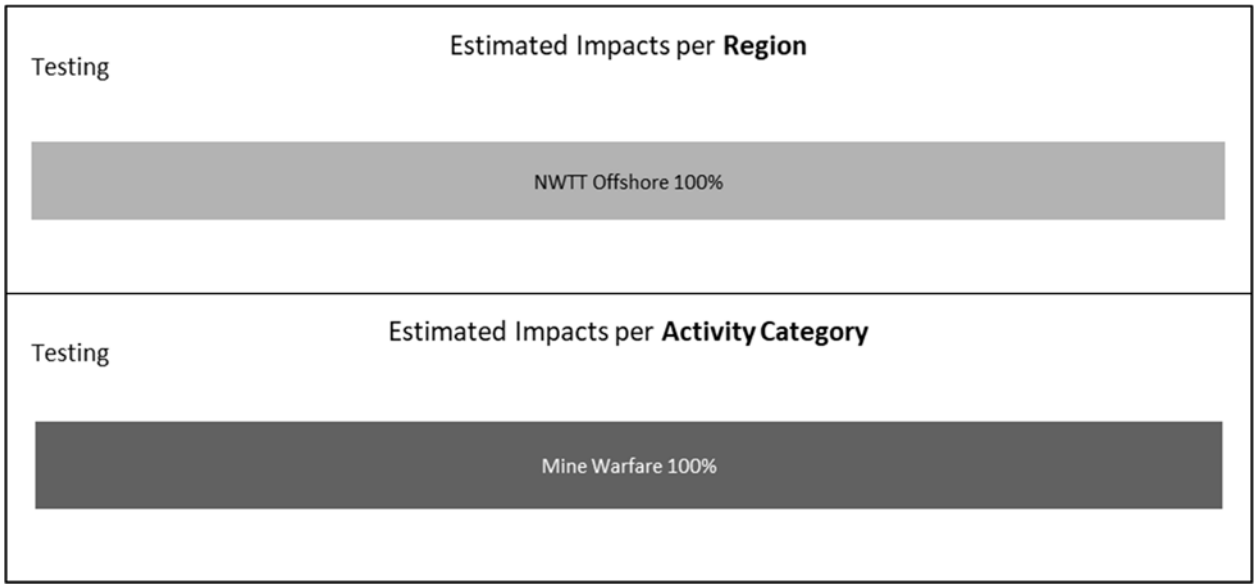
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of gray whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Gray whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions and TTS (see Figure 6-48 and Table 6-61). Impact ranges for this species are discussed in Section 6.5.2.2, Impact Ranges for Explosives. Estimated impacts apply to the Eastern North Pacific stock (see Table 6-61).

As described for mysticetes above, even a few minor to moderate behavioral impacts or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of gray whales incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-48: Gray Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-61: Estimated Impacts on Individual Gray Whale Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
Eastern North Pacific	0	0	0	0	1	2	0	0
Western North Pacific	0	0	0	0	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3 Odontocetes

Odontocetes may be exposed to sound and energy from explosives associated with training and testing activities throughout the year. Explosions produce sounds that are within the hearing range of odontocetes (see Section 6.3, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking, and hearing loss. Impact ranges for odontocetes exposed to explosive sound and energy are discussed in Section 6.5.2.2 (Impact Ranges for Explosives) under mid-frequency cetaceans for most species, and under high-frequency cetaceans for Kogia whales and Dall's porpoises.

Non-auditory injuries to odontocetes, if they did occur, could include anything from mild injuries that are recoverable and are unlikely to have long-term consequences, to more serious injuries, including mortality. It is possible for marine mammals to be injured or killed by an explosion in isolated instances. Animals that did sustain injury could have long-term consequences for that individual. Considering that dolphin species for which these impacts are predicted have populations with tens to hundreds of thousands of animals, removing several animals from the population would be unlikely to have measurable long-term consequences for the species or stocks. As discussed in Section 11.1.2 (Explosive Stressors), the Navy will implement procedural mitigation measures to delay or cease detonations when a marine mammal is sighted in a mitigation zone to avoid or reduce potential explosive impacts.

Odontocetes that do experience a hearing threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A threshold shift can take a few minutes to a few days, depending on the severity of the initial shift, to recover. TTS would recover fully, and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies equally and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the period that an odontocete had hearing loss, social calls from conspecifics and sounds from predators such as killer whale vocalizations could be more difficult to detect or interpret, although many of these sounds may be above the frequencies of the threshold shift. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few kHz, which are less likely to be affected by threshold shift at lower frequencies, and should not affect odontocete's ability to locate prey or rate of feeding.

Research and observations of masking in marine mammals due to impulsive sounds are discussed in Section 6.5.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in odontocetes that are nearby, although sounds from explosions last for only a few seconds at most. Also, odontocetes typically communicate, vocalize, and echolocate at higher frequencies that would be less affected by masking noise at lower frequencies such as those produced by an explosion. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations such as some naval gunfire exercises could create some masking for odontocetes in the area over the short duration of the event. Potential costs to odontocetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water and the effect is over the moment the sound has ceased.

Research and observations (see Section 6.5.1.5, Behavioral Reactions) show that odontocetes do not typically show strong behavioral reactions to impulsive sounds such as explosions. Reactions, if they did occur, would likely be limited to short ranges, within a few kilometers of multiple explosions. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short-term and intermittent, and because detonations usually occur within a small area, behavioral reactions from odontocetes are likely to be short-term and low to moderate severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 6.5.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

6.5.2.3.3.1 Common Bottlenose Dolphins

Impacts from Explosives Under the Proposed Action for Training Activities

Common bottlenose dolphins may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of common bottlenose dolphins.

Impacts from Explosives Under the Proposed Action for Testing Activities

Common bottlenose dolphins may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of common bottlenose dolphins.

6.5.2.3.3.2 Killer Whales (one DPS is Endangered Species Act-Listed)

For the populations of killer whales present in the Study Area, only the Southern Resident population is listed as endangered under the ESA.

Impacts from Explosives Under the Proposed Action for Training Activities

Killer whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Most, although not all, detonations would occur greater than 50 NM from shore in the Offshore Area of the NWTT Study Area. A very small number of mine neutralization training activities using small charges would occur in the Hood Canal Explosive Ordinance Disposal Range and Crescent Harbor Explosive Ordnance Range.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of killer whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Killer whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

All testing involving explosives will occur in the Offshore Area, and with the exception of mine countermeasure and neutralization testing (new testing activities in Phase III), will typically occur at distances greater than 50 NM from shore. There are no testing activities that involve the use of explosives in Inland Waters.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of killer whales.

6.5.2.3.3.3 Northern Right Whale Dolphins

Impacts from Explosives Under the Proposed Action for Training Activities

Northern right whale dolphins may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities (see Table 6-62). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

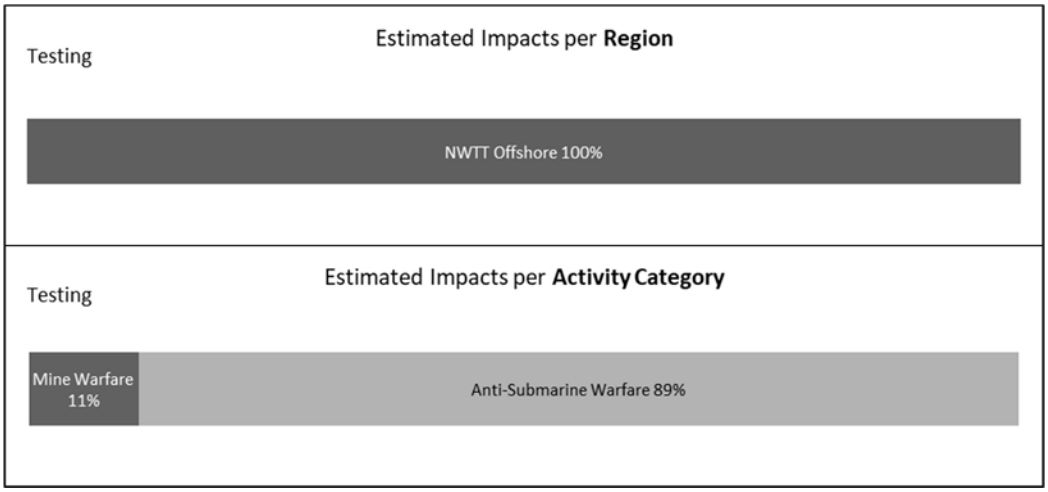
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of Northern right whale dolphins.

Impacts from Explosives Under the Proposed Action for Testing Activities

Northern right whale dolphins may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions and TTS (see Figure 6-49 and Table 6-62 below). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-62).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of Northern right whale dolphins incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-49: Northern Right Whale Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-62: Estimated Impacts on Individual Northern Right Whale Dolphin Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
California, Oregon, & Washington	0	0	0	0	1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.4 Pacific White-Sided Dolphins

Impacts from Explosives Under the Proposed Action for Training Activities

Pacific white-sided dolphins may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts from training activities (see Table 6-63). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

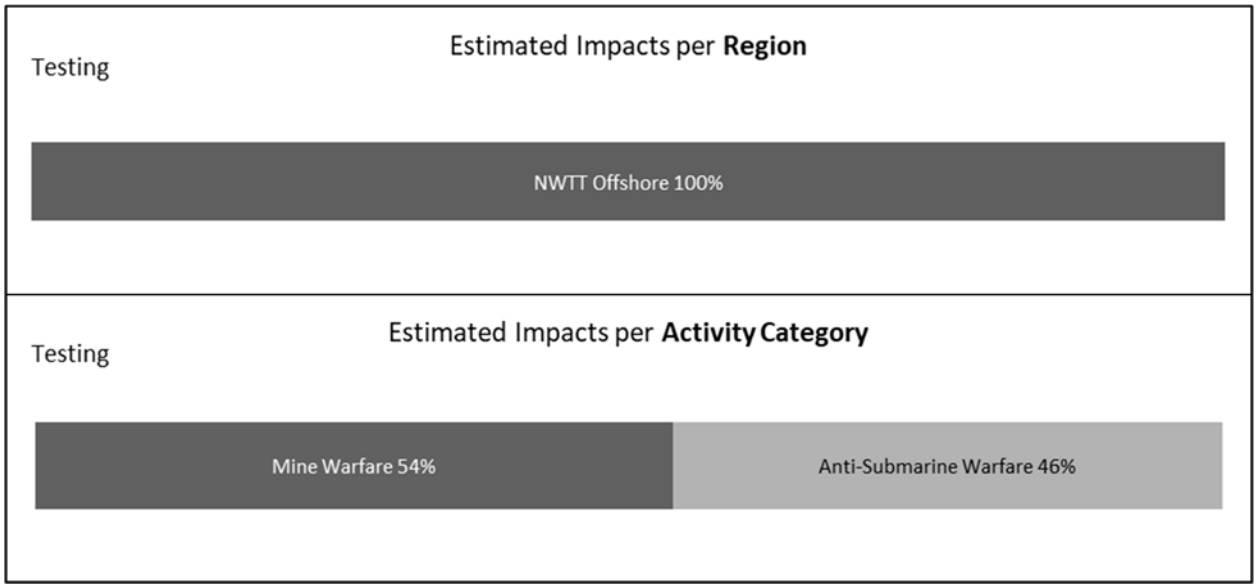
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of Pacific white-sided dolphins.

Impacts from Explosives Under the Proposed Action for Testing Activities

Pacific white-sided dolphins may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions and TTS (see Figure 6-50 and Table 6-63 below). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-63).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of Pacific white-sided dolphins incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-50: Pacific White-Sided Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-63: Estimated Impacts to Individual Pacific White-Sided Dolphin Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
California, Oregon, & Washington	0	0	0	0	1	1	0	0
North Pacific	0	0	0	0	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.5 Risso's Dolphins

Impacts from Explosives Under the Proposed Action for Training Activities

Risso's dolphins may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of Risso's dolphins.

Impacts from Explosives Under the Proposed Action for Testing Activities

Risso's dolphins may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of Risso's dolphins.

6.5.2.3.3.6 Short-Beaked Common Dolphin

Impacts from Explosives Under the Proposed Action for Training Activities

Short-beaked common dolphins may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of short-beaked common dolphins.

Impacts from Explosives Under the Proposed Action for Testing Activities

Short-beaked common dolphins may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of short-beaked common dolphins.

6.5.2.3.3.7 Short-Finned Pilot Whales

Impacts from Explosives Under the Proposed Action for Training Activities

Short-finned pilot whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of short-finned pilot whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Short-finned pilot whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of short-finned pilot whales.

6.5.2.3.3.8 Striped Dolphins

Impacts from Explosives Under the Proposed Action for Training Activities

Striped dolphins may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of striped dolphins.

Impacts from Explosives Under the Proposed Action for Testing Activities

Striped dolphins may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of striped dolphins.

6.5.2.3.3.9 Kogia Whales

Kogia whales include two species that are often difficult to distinguish from one another: dwarf sperm whales and pygmy sperm whales.

TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales, are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

Impacts from Explosives Under the Proposed Action for Training Activities

Kogia whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year

under the Proposed Action, estimates no impacts for training activities. Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

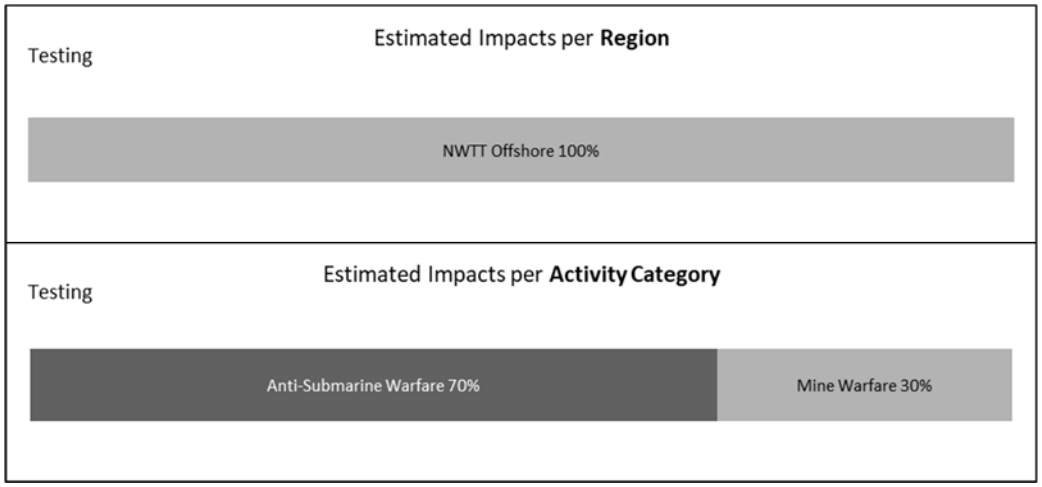
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of Kogia whales (dwarf and pygmy sperm whales).

Impacts from Explosives Under the Proposed Action for Testing Activities

Kogia whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts on dwarf sperm whales for training activities. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions, TTS, and PTS for pygmy sperm whales (see Figure 6-51 and Table 6-64 below). Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts to Kogia whales apply only to the California, Oregon, and Washington stocks.

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of Kogia whales (dwarf and pygmy sperm whales) incidental to those activities.



Notes: Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-51: Pygmy Sperm Whales Impacts Estimated per Year from the Maximum Number of Explosions During Testing Under the Proposed Action

Table 6-64: Estimated Impacts on Individual Pygmy Sperm Whale Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action.

Estimated Impacts by Effect								
Stock	Training				Testing			
	Behavioral	TTS	PTS	Injury	Behavioral	TTS	PTS	Injury
California, Oregon, & Washington	0	0	0	0	1	3	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.10 Dall's Porpoises

TTS and PTS thresholds for high-frequency cetaceans, such as Dall's porpoises, are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans.

Impacts from Explosives Under the Proposed Action for Training Activities

Dall's porpoises may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions, TTS, and PTS (see Figure 6-52 and tabular results in Section 5.1, Incidental Take Request from Acoustic and Explosive Sources). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-65).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will result in the unintentional taking of Dall's porpoises incidental to those activities.

Impacts from Explosives Under the Proposed Action for Testing Activities

Dall's porpoises may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions, TTS, and PTS (see Figure 6-52 and Table 6-65 below). Impact ranges for this species are discussed in Section 6.5.2.2, Impact Ranges for Explosives. Estimated impacts apply to the California, Oregon, and Washington stock (see Table 6-65).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of Dall's porpoises incidental to those activities.

Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-52: Dall's Porpoise Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-65: Estimated Impacts on Individual Dall's Porpoise Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
Alaska	0	0	0	0	0	0	0	0
California, Oregon, & Washington	4	16	2	0	52	175	66	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.11 Harbor Porpoises

TTS and PTS thresholds for high-frequency cetaceans, such as harbor porpoises, are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

Impacts from Explosives Under the Proposed Action for Training Activities

Harbor porpoises may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates TTS and PTS (see Figure 6-53 and Table 6-66 below). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2, Impact Ranges for Explosives. Estimated impacts apply to the Washington Inland Waters stock (see Table 6-66).

As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will result in the unintentional taking of harbor porpoises incidental to those activities.

Impacts from Explosives Under the Proposed Action for Testing Activities

Harbor porpoises may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions, TTS, and PTS (see Figure 6-53 and Table 6-66

below). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to multiple stocks (see Table 6-66).

As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of harbor porpoises incidental to those activities.

Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-53: Harbor Porpoise Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-66: Estimated Impacts on Individual Harbor Porpoise Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
Southeast Alaska	0	0	0	0	0	0	0	0
Northern Oregon/ Washington Coast	0	0	0	0	52	178	79	0
Northern California /Southern Oregon	0	0	0	0	91	214	86	0
Washington Inland Waters	0	61	27	0	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.12 Sperm Whales (Endangered Species Act-Listed)

Impacts from Explosives Under the Proposed Action for Training Activities

Sperm whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of sperm whales.

Impacts from Explosives Under the Proposed Action for Testing Activities

Sperm whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of sperm whales.

6.5.2.3.3.13 Beaked Whales

Beaked whales within the NWTT study area include Baird's beaked whale, Blainville's beaked whale, Cuvier's beaked whale, Hubb's beaked whale, ginkgo-toothed beaked whale, Perrin's beaked whale, Stejneger's beaked whale, and the pygmy beaked whale. Impacts to Blainville's beaked whale, Hubb's beaked whale, ginkgo-toothed beaked whale, Perrin's beaked whale, Stejneger's beaked whale, and the pygmy beaked whale are combined and represented in the beaked whale guild (*Mesoplodon spp*.).

Research and observations (see Section 6.5.2.1.1.4, Behavioral Responses from Explosives) show that beaked whales are sensitive to human disturbance including noise from sonars, although no research on specific reactions to impulsive sounds or noise from explosions is available. Odontocetes overall have shown little responsiveness to impulsive sounds, although it is likely that beaked whales are more reactive than most other odontocetes. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Beaked whales on Navy ranges have been observed leaving the area for a few days during sonar training exercises. It is reasonable to expect that animals may leave an area of more intense explosive activity for a few days; however, most explosive use during Navy activities is short duration, consisting of only a single or few closely timed explosions (i.e., detonated within a few minutes) with a limited footprint due to a single detonation point. Because noise from most activities using explosives is short-term and intermittent and because detonations usually occur within a small area, behavioral reactions from beaked whales are likely to be short term and moderate severity.

Impacts from Explosives Under the Proposed Action for Training Activities

Beaked whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities for Baird's beaked whale, Cuvier's beaked whale, or the small beaked whale guild (*Mesoplodon spp*.). Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be conducted as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of Baird's beaked whale, Cuvier's beaked whale, or the small beaked whale guild (Mesoplodon spp.).

Impacts from Explosives Under the Proposed Action for Testing Activities

Beaked whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities for Baird's beaked whale, Cuvier's beaked whale, or the small beaked whale guild (*Mesoplodon spp*.). Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of Baird's beaked whale, Cuvier's beaked whale, or the small beaked whale guild (Mesoplodon spp.).

6.5.2.3.4 Pinnipeds

Pinnipeds include phocid seals (true seals) and otariids (sea lions and fur seals).

If a pinniped was to experience TTS from explosive sounds, it may have a reduced ability to detect biologically important sounds until their hearing recovers. Recovery from TTS begins almost immediately after the noise exposure ceases and can take a few minutes to a few days, depending on the severity of the initial shift, to fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the short period that a pinniped had TTS, social calls from conspecifics could be more difficult to detect or interpret; however; most pinniped vocalizations may be above the frequency of TTS induced by an explosion. Killer whales are one of the pinniped primary predators. Killer whale vocalizations are typically above a few kHz, well above the region of hearing that is likely to be affected by exposure to explosive energy. Therefore, TTS in pinnipeds due to sound from explosions is unlikely to reduce detection of killer whale calls. Pinnipeds may use sound underwater to find prey and feed; therefore, a TTS could have a minor and temporary effect on a phocid seal's ability to locate prey.

Research and observations of auditory masking in marine mammals due to impulsive sounds are discussed in Section 6.5.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in pinnipeds that are nearby, although sounds from explosions last for only a few seconds at most. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations, such as some naval gunfire exercises, could create some masking for pinnipeds in the area over the short duration of the event. Potential costs to pinnipeds from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water; the effect is over the moment the sound has ceased.

Research and observations (see Section 6.5.2.1.1.4, Behavioral Responses from Explosives) show that pinnipeds may be the least sensitive taxonomic group to most noise sources. They are likely to only respond to loud impulsive sound sources at close ranges by startling, jumping into the water when hauled out, or even cease foraging, but only for brief periods before returning to their previous behavior. Pinnipeds may even experience TTS before exhibiting a behavioral response (Southall et al., 2007). Because noise from most activities using explosives is short term and intermittent, and because detonations usually occur within a small area, behavioral reactions from phocid seals are likely to be short term and low severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 6.5.1.3, (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

6.5.2.3.4.1 California Sea Lions

Impacts from Explosives Under the Proposed Action for Training Activities

California sea lions may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities (see Table 6-67). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

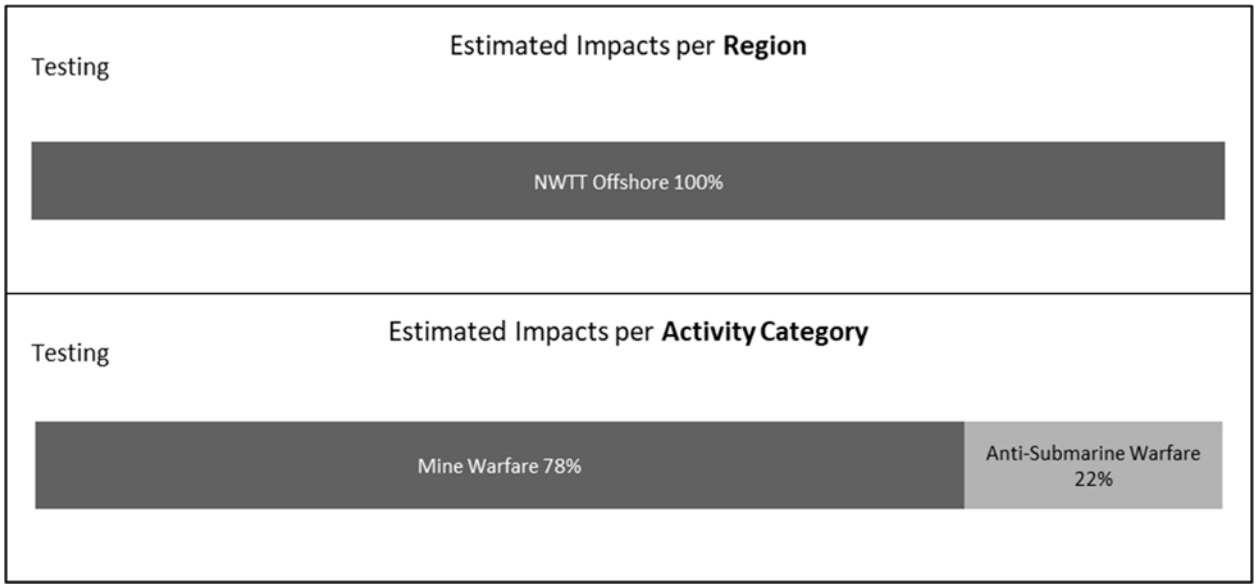
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of California sea lions.

Impacts from Explosives Under the Proposed Action for Testing Activities

California sea lions may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates behavioral reactions, TTS, PTS (see Figure 6-54 and Table 6-67 below). Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the U.S. stock (see Table 6-67).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of California sea lions incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-54: California Sea Lion Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-67: Estimated Impacts on Individual California Sea Lion Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
U.S. Stock	0	0	0	0	1	3	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.4.2 Steller Sea Lions (one DPS is Endangered Species Act-Listed)

The Eastern U.S. stock of Steller sea lions is not listed under the Endangered Species Act. All impacts estimated by the quantitative analysis are on the Eastern U.S. stock. The Western U.S. stock of Steller sea lions is listed endangered under the ESA; however, Steller sea lions from the Western U.S. stock are rare in the Study Area.

Impacts from Explosives Under the Proposed Action for Training Activities

Steller sea lions may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year

under the Proposed Action, estimates no impacts for training activities (see Table 6-68). Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

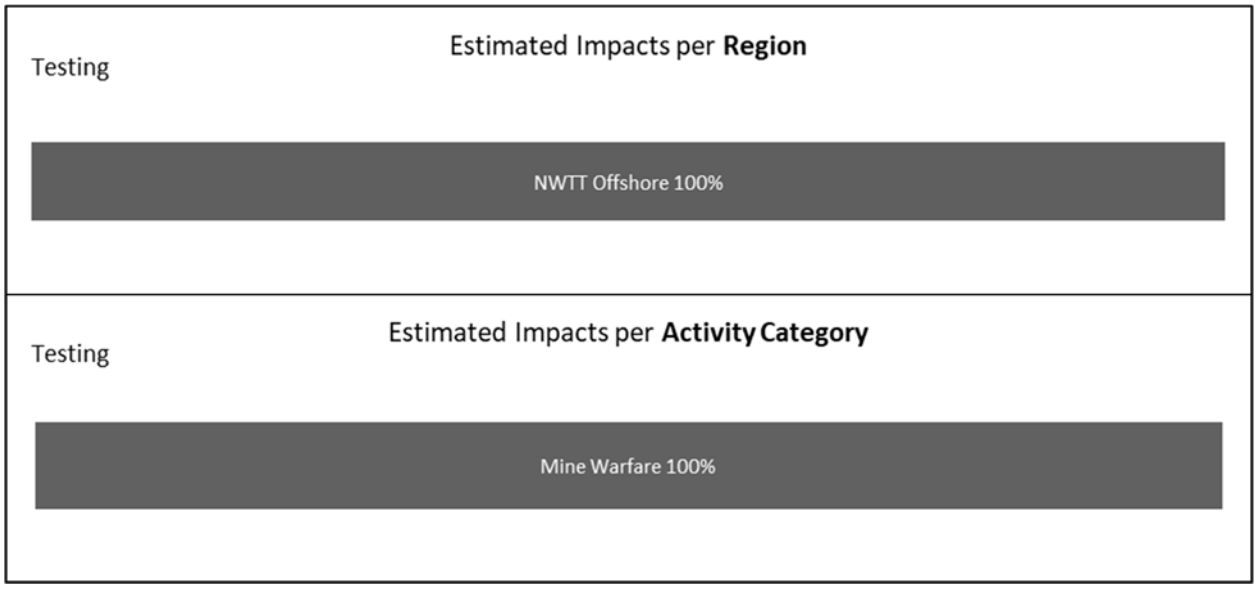
The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of Steller sea lions.

Impacts from Explosives Under the Proposed Action for Testing Activities

Steller sea lions may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates TTS (see Figure 6-55 and Table 6-68 below. Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Eastern U.S. stock (see Table 6-68).

As described above, even a few minor to moderate TTS reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of Steller sea lions incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-55: Steller Sea Lion Impacts Estimated per Year from the Maximum Number of Explosions During Testing Under the Proposed Action

Table 6-68: Estimated Impacts on Individual Steller Sea Lion Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	*Training*				*Testing*			
	Behavioral	*TTS*	*PTS*	*Injury*	*Behavioral*	*TTS*	*PTS*	*Injury*
Eastern U.S.	0	0	0	0	0	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.4.3 Guadalupe Fur Seals (Endangered Species Act-listed)

Impacts from Explosives Under the Proposed Action for Training Activities

Guadalupe fur seals may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for training activities. Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training or testing activities as described under the Proposed Action will not result in the incidental taking of Guadalupe fur seals.

Impacts from Explosives Under the Proposed Action for Testing Activities

Guadalupe fur seals may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities. Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of Guadalupe fur seals.

6.5.2.3.4.4 Northern Fur Seals

Impacts from Explosives Under the Proposed Action for Training Activities

Northern fur seals may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per

year under the Proposed Action, estimates no impacts for training activities. Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will not result in the incidental taking of northern fur seals.

Impacts from Explosives Under the Proposed Action for Testing Activities

Northern fur seals may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates no impacts for testing activities (see tabular results in Section 5.1, Incidental Take Request from Acoustic and Explosive Sources). Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will not result in the incidental taking of northern fur seals.

6.5.2.3.4.5 Harbor Seals

Impacts from Explosives Under the Proposed Action for Training Activities

Harbor seals may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates TTS and PTS (see Figure 6-56 and Table 6-69 below). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to multiple stocks (see Table 6-69).

As described above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during training activities as described under the Proposed Action will result in the unintentional taking of harbor seals incidental to those activities.

Impacts from Explosives Under the Proposed Action for Testing Activities

Harbor seals may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year

under the Proposed Action, estimates behavioral reactions, TTS, and PTS (see Figure 6-56 and Table 6-69). Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to multiple stocks (see Table 6-69).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of harbor seals incidental to those activities.

Notes: Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-56: Harbor Seal Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-69: Estimated Impacts on Individual Harbor Seal Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
Hood Canal	0	4	1	0	0	0	0	0
Oregon/ Washington Coastal	0	0	0	0	8	9	2	0
Southeast Alaska - Clarence Strait	0	0	0	0	0	0	0	0
Southern Puget Sound	0	0	0	0	0	0	0	0
Washington Northern Inland Waters	0	30	5	0	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.4.6 Northern Elephant Seals

Impacts from Explosives Under the Proposed Action for Training Activities

Northern elephant seals may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under the Proposed Action, estimates TTS and PTS (see Figure 6-57 and Table 6-70 below). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the California stock (see Table 6-70).

As described above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during training activities as described under the Proposed Action will result in the unintentional taking of northern elephant seals incidental to those activities.

Impacts from Explosives Under the Proposed Action for Testing Activities

Northern elephant seals may be exposed to sound or energy from explosions associated with testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per

year under the Proposed Action, estimates behavioral reactions, TTS, and PTS (see Figure 6-57 and Table 6-70 below). Impact ranges for these species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the California stock (see Table 6-70).

As described above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

The use of explosives during testing activities as described under the Proposed Action will result in the unintentional taking of northern elephant seals incidental to those activities.

Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99-101 percent. Estimated impacts most years would be less based on fewer explosions.

Figure 6-57: Northern Elephant Seal Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6-70: Estimated Impacts on Individual Northern Elephant Seal Stocks Within the Study Area per Year from Training and Testing Explosions Using the Maximum Number of Explosions Under the Proposed Action

Estimated Impacts by Effect								
Stock	***Training***				***Testing***			
	Behavioral	***TTS***	***PTS***	***Injury***	***Behavioral***	***TTS***	***PTS***	***Injury***
California	0	2	1	0	7	8	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.6 VESSEL STRIKE ANALYSIS

Reviews of the literature on vessel strikes mainly involve collisions between commercial vessels and whales (Cascadia Research, 2017c; Currie et al., 2017; Douglas et al., 2008; Jensen & Silber, 2004; Laist et al., 2001; Lammers et al., 2013; Monnahan et al., 2015; Nichol et al., 2017; Rockwood et al., 2017). The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and manning, as well as the behavior of the animal (Conn & Silber, 2013; Currie et al., 2017; Gende et al., 2011; Silber et al., 2010; Vanderlaan & Taggart, 2007; Wiley et al., 2016). In areas of both high whale density and a high volume of vessel traffic, such as the Strait of Juan de Fuca and its entrance, whales are predicted to be susceptible to elevated risk for vessel strike (Nichol et al., 2017).

Large Navy vessels (greater than 18 m in length) within the Offshore Area of the Study Area operate differently from commercial vessels in ways important to the prevention of whale collisions. For example, in the open ocean the average speed of large Navy ships ranges between 10 and 15 knots, and submarines generally operate at speeds in the range of 8 and 13 knots, while a few specialized vessels can travel at faster speeds. By comparison, this is slower than most commercial vessels where normal design speed for a container ship is typically 24 knots (Bonney & Leach, 2010). Even given the advent of "slow steaming" by commercial vessels in recent years due to fuel prices (Barnard, 2016; Maloni et al., 2013), this generally reduces the design speed by only a few knots, given that 21 knots would be considered slow, 18 knots is considered "extra slow," and 15 knots is considered "super slow" (Bonney & Leach, 2010). Small Navy craft (less than 50 ft. in length), have much more variable speeds (0–50 knots or more, depending on the mission). While these speeds are considered averages and representative of

most events, some Navy vessels need to operate outside of these parameters during certain situations. Differences between most military ships and commercial ships also include the following disparities:

- The Navy has several standard operating procedures for vessel safety that could result in a secondary benefit to marine mammals through a reduction in the potential for vessel strike. For example, ships operated by or for the Navy have personnel assigned to stand watch at all times, day and night, when moving through the water (i.e., when the vessel is underway). Watch personnel undertake extensive training in accordance with the U.S. Navy Lookout Training Handbook or civilian equivalent. A primary duty of watch personnel is to ensure safety of the ship, which 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, surfaced submarine, or 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. Military vessels are required to operate in accordance with applicable navigation rules. Applicable rules include the Inland Navigation Rules (33 Code of Federal Regulations 83) and International Regulations for Preventing Collisions at Sea (72 Collision Regulations), which were formalized in the Convention on the International Regulations for Preventing Collisions at Sea, 1972. Further, Navy vessels operate in accordance with the navigation rules established by the U.S. Coast Guard. All vessels operating on the water are required to follow the International Navigation Rules (COMDTINST M16672.2D). These rules require that vessels proceed at a safe speed so proper and effective action can be taken to avoid collision and so vessels can be stopped within a distance appropriate to the prevailing circumstances and conditions. In addition to complying with navigation requirements, Navy ships transit at speeds that are optimal for fuel conservation, to maintain ship schedules, and to meet mission requirements. Vessel captains use the totality of the circumstances to ensure the vessel is traveling at appropriate speeds in accordance with navigation rules. Depending on the circumstances, this may involve adjusting speeds during periods of reduced visibility or in certain locations.
- Many military ships have their bridges positioned closer to the bow, offering good visibility ahead of the ship.
- There are often aircraft associated with the training or testing activity, which can detect marine mammals in the vicinity or ahead of a vessel's present course.
- Military ships are generally much more maneuverable than commercial merchant vessels if marine mammals are spotted and it becomes necessary to change direction.
- Military ships operate at the slowest speed possible consistent with either transit needs, or training or testing need. While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include being better able to spot and avoid objects in the water, including marine mammals.
- In many cases, military ships will likely move randomly or with a specific pattern within a sub-area of the Study Area for a period of time, from one day to two weeks, as compared to straight line point-to-point commercial shipping.
- Military overall crew size is much larger than merchant ships, allowing for more potential observers on the bridge.
- When submerged, submarines are generally slow moving (to avoid detection), and therefore marine mammals at depth with a submarine are likely able to avoid collision with the

submarine. When a submarine is transiting on the surface, there are Lookouts serving the same function as they do on surface ships.

- The Navy will implement mitigation to avoid potential impacts from vessel strikes on marine mammals (see Chapter 11, Mitigation Measures). Mitigation includes training Lookouts and watch personnel with the Marine Species Awareness Training (which provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures), requiring vessels to maneuver to maintain a specified distance from marine mammals during vessel movements.

Data from the ports of Vancouver, British Columbia; Seattle, Washington; and Tacoma, Washington indicated there were in excess of 7,000 commercial vessel transits in 2017 associated with visits to just those ports (The Northwest Seaport Alliance, 2018; Vancouver Fraser Port Authority, 2017). This number of vessel transits does not account for other vessel traffic in the Strait of Juan de Fuca or Puget Sound resulting from commercial ferries, tourist vessels, or recreational vessels. Additional commercial traffic in the Study Area also includes vessels transiting offshore along the Pacific coast, bypassing ports in Canada and Washington; traffic associated with ports to the south along the coast of Washington and in Oregon; and vessel traffic in Southeast Alaska (Nuka Research & Planning Group, 2012). This level of commercial vessel traffic for the ports of Vancouver, Seattle, and Tacoma is approximately the same as was presented during consultation in 2015.

In the Study Area, the existing marine environment is dominated by non-military vessel traffic given the Navy has, in total, the following homeported operational vessels: 2 aircraft carriers, 6 destroyers, 14 submarines, and 22 smaller security vessels with a combined annual total of 241 Navy vessel transits. Appendix A (Navy Activities Descriptions) of the Draft Supplemental EIS/OEIS describes the number of vessels used during the various types of Navy's proposed activities. Activities involving military vessel movement would be widely dispersed throughout the Study Area.

Many marine mammals in the Study Area (especially large whales) have seasonal ranges that include the remainder of the U.S. West Coast, Hawaii, and Alaska (beyond the Behm Canal portion of the Study Area). Between 1986 and 2017, there have been 12 fin whales killed as a result of vessel strikes found in the Inland Waters portion of the Study Area (Towers et al., 2018). For the latest five-year reporting periods, NMFS Technical Memoranda documented 65 vessel strikes to marine mammals off the U.S West Coast (Washington and California) (Carretta et al., 2017b), 38 vessel strikes to humpback whales in Hawaii (Bradford & Lyman, 2015), and approximately 14 vessel strikes to marine mammals in Alaska (Helker et al., 2017).

Navy policy (Chief of Naval Operations Instruction 3100.6 H) is to report all whale strikes by Navy vessels. By information agreement, that information has been provided to NMFS on an annual basis. Only the Navy and the U.S. Coast Guard report vessel strike to NMFS in this manner, so all statistics are skewed by a lack of comprehensive reporting by all vessels that may experience vessel strike.

Vessel strike records from the Navy have been kept since 1995, and there have been two Navy vessel strikes to marine mammals in the NWTT Study Area, up to and through January 2019.

The fate of the two whales that were struck by Navy vessels in the Study Area is unknown. Although it does not preclude the possibility that a serious injury or mortality may have occurred, in neither of these two cases were there indications of serious injuries; there was no blood in the water, the whales did not appear injured, and there were no whale strandings or mortalities reported within an associated time

frame in the Study Area. For purposes of the analysis in this request for LOAs, it is assumed that any whale struck by any vessel would have sustained serious injury or mortality, although evidence of whales displaying diagnostic but healed injuries and scars indicates that some struck whales may survive, dependent on a variety of factors (Bradford & Lyman, 2015; Carretta et al., 2017b; Fulling et al., 2017; Helker et al., 2017; Ritter, 2012; Rockwood et al., 2017; Towers et al., 2018; Van Waerebeek et al., 2007).

The projected military vessel use has not significantly changed over time and is not projected to significantly change under the Proposed Action. Integration of the Navy's Marine Species Awareness Training began in 2007 and was fully integrated across the Navy by 2009, resulting in a decrease in strike incidents Navy-wide. These factors and adaptation of additional mitigation measures since 2009 makes the period since 2009 the most appropriate for calculation of future expected strikes; while the Navy does not anticipate vessel strikes to marine mammals within the NWTT Study Area during the proposed activities, military vessel strikes in the Study Area for the period between 2009 and 2018 can be used to determine a statistical probability of future military vessel strike as a rate parameter of a Poisson distribution. To estimate the probability of 0, 1, 2, 3,… n vessel strikes involving Navy vessels over the time period considered in this request for LOAs, a simple computation can be generated: $P(X) = P(X-1)\mu/X$, where P(X) is the probability of occurrence in a unit of time (or space) and μ is the number of occurrences in a unit of time (or space). For the 10-year period from 2009 through 2018 there were 849 Navy vessel steaming days, if μ is based on two strikes over 849 steaming days in the 10 years (2/849=0.00355) then $\mu = 0.002355$. Plugging 0.002355 into the $P(0) = e\text{-}\mu$ yields a values of P(0)=0.002355 strikes per steaming day; and estimated probability of 1.36 military vessel strikes over a 7-year period in NWTT. As shown in Table 6-71, within any given year during the period of time considered in this LOA Application, there is approximately a 26 percent probability that no Navy vessel strikes will occur, a 35 percent chance one strike would occur, a 24 percent chance of two strikes, and an 11 percent chance of three strikes over the 7-year period.

Table 6-71: Poisson Probability of Striking "X" Number of Whales When Expecting 1.36 Total Strikes over a 7-year Period in the NWTT Study Area

Predicted Number of Strikes Per Year	NWTT Study Area
No strikes	26%
1 strike	35%
2 strikes	24%
3 strikes	11%

Under the Proposed Action in NWTT, the proposed activities would not result in any appreciable changes from the frequency and manner in which the Navy has operated vessels and would remain consistent with the range of variability observed over the last decade. Consequently, the Navy is not significantly changing the locations or frequency at which vessels are used and therefore does not anticipate a change in the number of strikes expected to occur.

Based on the analysis presented above, the use of vessels during training and testing activities may result in the incidental taking of marine mammals. Navy is therefore seeking authorization for a take to account for the possibility of an accidental strike and the potential risk associated with any military

vessel movement within the Study Area. The Navy will request authorization for mortality or serious injury from vessel strike over the 7 year period provided in this analysis for three (3) ship strike takes to the following species: blue whale, fin whale, Eastern North Pacific gray whale, Hawaii DPS humpback whale, minke whale, sei whale, or sperm whale.

7 Anticipated Impact of the Activity

Consideration of negligible impact to the species or stock is required for NMFS to authorize incidental take of marine mammals. An activity has a 'negligible impact' on a species or stock when the activity 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 Navy concludes that training and testing activities proposed in the Study Area would result in Level B and Level A takes, as summarized in Section 5.1 (Incidental Take Request from Acoustic and Explosive Sources). Based on best available science, the Navy concludes that exposures to marine mammal species and stocks due to training and testing activities would result in only short-term effects on most individuals exposed and would not affect annual rates of recruitment or survival for the following reasons:

- Most acoustic exposures are within the non-injurious temporary threshold shift or behavioral effects zones (Level B harassment).
- Although the numbers presented in Table 5-1 represent estimated harassment under the MMPA, they are conservative estimates (i.e., overpredictions) of harassment, primarily by behavioral disturbance.
- The Navy Acoustic Effects Model calculates harassment without taking into consideration mitigation measures, and is not indicative of a likelihood of either injury or harm. Additionally, the mitigation measures described in Chapter 11 (Mitigation Measures) are designed to avoid or reduce sound exposure and explosive effects on marine mammals to achieve the least practicable adverse effect on marine mammal species or stocks.

This request for LOAs assumes that short-term non-injurious sound exposure levels predicted to cause onset-TTS or temporary behavioral disruptions (non-TTS) qualify as Level B harassment. While many of these exposures would likely not rise to the level of the National Defense Authorization Act definition of Level B harassment, the Navy has no mechanism to quantify actual Level B harassment. The assumption that exposures predicted to cause behavioral disruptions would qualify as Level B harassment results in an overestimate of reactions qualifying as harassment under MMPA because there is no definitive level of exposure to acoustic energy associated with short-term sonar use or underwater detonations that clearly results in long-term abandonment or significant alteration of behavioral patterns in marine mammals.

7.1 Long-term Consequences to Species and Stocks

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. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual, or for very small populations to the population as a whole; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result

of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al., 2003). Highly resident or localized populations may also stay in an area of disturbance because the cost of displacement may be higher than the cost of remaining (Forney et al., 2017). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al., 2006b; Blackwell et al., 2004; Teilmann et al., 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al., 1984). Mysticetes in the northeast tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins, 1986), indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. West Coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound including the use of sonar by the U.S. Navy; however, new data has been published that raises uncertainties over whether a decline in the beaked whale population occurred off the U.S. West Coast between 1996 and 2014 (Barlow, 2016). Moore and Barlow (2017) have since incorporated information from the entire 1991 to 2014 time series, which suggests an increasing abundance trend and a reversal of the declining trend along the U.S. West Coast that had been noted in their previous (2013) analysis.

In addition, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blainville's beaked whales may be resident during all or part of the year in the area. Individuals may move off the range for several days during and following a sonar event, but return within a few days (McCarthy et al., 2011; Tyack et al., 2011). Photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to seven years apart (Falcone et al., 2009; Falcone & Schorr, 2014). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact on population growth rates, and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of these was associated with her second calf; and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et

al., 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the Southern California Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of kilometers by some of those animals. Schorr et al. (2014) reported the results for an additional eight tagged Cuvier's beaked whales in the same area. Five of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km south to Mexico and back again. Given that some beaked whales may routinely move hundreds of kilometers as part of their normal pattern (Schorr et al., 2014), temporarily leaving an area to avoid sonar or other anthropogenic activity may have little cost.

Another approach to investigating long-term consequences of anthropogenic noise exposure has been an attempt to link short-term effects to individuals from anthropogenic stressors with long-term consequences to populations using population models. Population models are well known from many fields in biology, including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population, such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known. (Nowacek et al., 2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and, ultimately, population-level effects. The linkage between immediate behavioral or physiological effects to an individual due to a stressor such as sound, the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and in turn the consequences for the population have been reviewed in National Research Council (2005).

The Population Consequences of Acoustic Disturbance model (National Research Council 2005) proposes a conceptual model for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al., 2016a; Costa et al., 2016b; Harwood & King, 2014; Hatch et al., 2012; King et al., 2015; New et al., 2013a; New et al., 2013b; New et al., 2014). Currently, the Population Consequences of Disturbance model provides a theoretical framework and identifies types of data that would be needed to assess population-level impacts using this process. The process is complicated and provides a foundation for the type of data that is needed, which is currently lacking for many marine mammal species. Relevant data needed for improving these analytical approaches for population-level consequences resulting from disturbances will continue to be collected during projects funded by the Navy's marine species monitoring program.

Costa et al. (2016a) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory, or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance, can lead to markedly different impact results. For example, Costa et al. (2016a)

modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent, respectively, of each population would be exposed, and less than 19 percent and 6 percent, respectively, of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, but 100 percent of their foraging time would occur during an exposure when the zone was 25 km or more. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Energetic costs were estimated for western gray whales that migrated to possible wintering grounds near China or to the Baja California wintering grounds of eastern gray whales versus the energetic costs of the shorter migration of eastern gray whales (Villegas-Amtmann et al., 2017). Researchers found that when the time spent on the breeding grounds was held constant for both populations, the energetic requirements for the western gray whales were estimated to be 11 percent and 15 percent greater during the migration to Baja California and China, respectively, than for the migration of eastern gray whales, and therefore this population would be more sensitive to energy lost through disturbance.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the extreme and unlikely assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts on the population size and no long-term effects on population viability. Similarly, King et al. (2015) developed a Population Consequences of Disturbance framework using expert elicitation data on impacts from wind farms on harbor porpoises and, even under the worst-case scenarios, predicted less than a 0.5 percent decline in harbor porpoise populations. Nabe-Nelson et al. (2014) also modeled the impact of noise from wind farms on harbor porpoises and predicted that even when assuming a 10 percent reduction in population size if prey is impacted up to two days, the presence of ships and wind turbines did not deplete the population. In contrast, Heinis and De Jong (2015) used the Population Consequences of Disturbance framework to estimate impacts from both pile driving and seismic exploration on harbor porpoises and found a 23 percent decrease in population size over six years, with an increased risk for further reduction with additional disturbance days. These seemingly contradictory results demonstrate that refinements to models need to be investigated to improve consistency and interpretation of model results.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy-dense prey and high-quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival; however, the authors were forced to use many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more, indicating that temporary displacement from a small area may not preclude finding energy-dense prey or high-quality habitat. Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips (only

a 0.4 percent population decline in the following year). It should be noted that, in all of these models, assumptions were made and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population-level effects.

The best assessment of long-term consequences from Navy training and testing activities will be to monitor the populations over time within the Study Area. A U.S. workshop on Marine Mammals and Sound (Fitch et al., 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed and implemented comprehensive monitoring plans since 2009 for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's mitigation measures. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (e.g., Martin et al., 2017). Preliminary results of this analysis at the Pacific Missile Range Facility off Kauai, Hawaii indicate no changes in detection rates for several species over the past decade, demonstrating that Navy activities may not be having long-term population-level impacts. This type of analysis can be expanded to the other Navy ranges, such as the MIRC. Continued analysis of this 15-year dataset and additional monitoring efforts over time are necessary to fully understand the long-term consequences of exposure to military testing and training activities.

7.2 The Context of Behavioral Disruption, TTS, and PTS – Biological Significance to Populations

The exposure estimates calculated by predictive models currently available reliably predict propagation of sound and received levels and measure a short-term, immediate response of an individual or the potential for injury to an individual using applicable criteria. Consequences to populations are much more difficult to predict, and empirical measurement of population effects from anthropogenic stressors is limited (King et al., 2015; National Research Council, 2005). However, recent research concludes that it is theoretically possible to implement monitoring that assesses the chain of potential relations from initiation of a human activity to population dynamics—from physical and behavioral responses to the activity, to shifts in health, and to changes in vital rates (Fleishman et al., 2016). In practice, the primary impediment to predicting indirect, long-term, and cumulative effects, is that the processes must be well understood and the underlying data available for models. In response to the National Research Council review (2005), the Office of Naval Research founded a working group to formalize the PCAD framework. In addition, Navy-funded efforts and other research efforts are underway to try to improve understanding of and the ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; New et al., 2013b; Pirotta et al., 2015a). With respect to acoustically induced stress, this includes not only determining how and to what degree various types of anthropogenic sound cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the mammal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether it is naïve or experienced with the sound (e.g., prior experience with a stressor may result in a reduced response due to habituation) (Finneran & Branstetter, 2013; St. Aubin & Dierauf, 2001). Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, the Navy assumes in its effect analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response. The long-term goal is to

improve the understanding of how effects of marine sound on marine mammals transfer between behavior and life functions and between life functions and vital rates. This understanding will facilitate assessment of the population level effects of anthropogenic sound on marine mammals. This field and development of a state-space model is ongoing.

Based on each species' life history information, expected behavioral patterns in the Study Area, and the application of mitigation procedures proposed in Chapter 11 (Mitigation Measures), NWTT training and testing activities are anticipated to have a negligible impact on marine mammal populations within the Study Area.

8 Anticipated Impacts on Subsistence Uses

Potential marine mammal impacts resulting from the Proposed Action in the NWTT Study Area will be limited to individuals present in the Study Area and where no marine mammal subsistence uses exist. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

9 Anticipated Impacts on Habitat

Activity components with the potential to impact marine mammal habitat as a result of the Proposed Action include (1) changes in water quality, (2) the introduction of sound into the water column, and (3) temporary changes to prey distribution and abundance. Each of these components was considered in the NWTT Draft Supplemental EIS/OEIS and was determined to have no impact on marine mammal habitat. A summary of the conclusions is included below.

Water Quality. The NWTT Draft Supplemental EIS/OEIS analyzed the potential effects on water quality from military expended materials. Training and testing activities may introduce contaminants into the water column. Based on the analysis of the NWTT Draft Supplemental EIS/OEIS, military expended materials (e.g., undetonated explosive materials) would be released in quantities and at rates that would not result in a violation of any water quality standard or criteria. High-order explosions consume most of the explosive material, creating typical combustion products (Carr & Nipper, 2003; Hewitt et al., 2003; Juhasz & Naidu, 2007; Walker et al., 2006). For example, in the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents, and the remainder are rapidly degraded below threshold effect level (Juhasz & Naidu, 2007; Walker et al., 2006). Explosion by-products associated with high order detonations present no secondary stressors to marine mammals through sediment or water.

Indirect effects of explosives and unexploded ordnance to marine mammals via sediment are not expected, even in the immediate vicinity of the ordnance (Briggs et al., 2016; Edwards et al., 2016; Environmental Sciences Group, 2005; Kelley et al., 2016; Koide et al., 2015; U.S. Department of the Navy, 2013c; University of Hawaii, 2010). Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). Any remnant undetonated components from explosives such as TNT, royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems (Cruz-Uribe et al., 2007; Juhasz & Naidu, 2007; Pavlostathis & Jackson, 2002; Singh et al., 2009; Walker et al., 2006). Furthermore, while explosives and their degradation products were detectable in marine sediment next to degrading unexploded ordnance, the concentrations of these compounds were not statistically distinguishable from the natural background found in control samples taken from the environment around the degrading ordnance (Briggs et al., 2016; Edwards et al., 2016; Environmental Sciences Group, 2005; Kelley et al., 2016; Koide et al., 2015; U.S. Department of the Navy, 2013c; University of Hawaii, 2010).

Equipment used by the Navy within the Study Area, including ships and other marine vessels, aircraft, and other equipment, are also potential sources of contaminants. All equipment is properly maintained in accordance with applicable Navy or legal requirements. All such operating equipment meets federal water quality standards, where applicable.

Sound in the Water Column. Various activities and events, both natural and anthropogenic, above and below the water's surface contribute to oceanic ambient or background noise. Anthropogenic noise in the area from non-Navy sources includes commercial shipping and recreational boats. Low-frequency (15–30 Hz) ambient noise peaks during fall and winter and is likely due to seasonal presence of vocalizing mysticetes (Hill et al., 2015; Hill et al., 2016a; Hill et al., 2016b; Hill et al., 2017; Klinck et al., 2015b; Munger et al., 2015; Nieukirk et al., 2016; Norris et al., 2017; Oleson et al., 2015; Yack et al., 2016).

Anthropogenic noise attributable to Navy training and testing activities in the Study Area emanates from multiple sources, including sonar and other transducers, in-water detonations, as well as from other incidental sounds such as vessels, aircraft, weapons, and explosions in air. Sound produced from training and testing activities in the Study Area is temporary and transitory, and the affected area would be expected to immediately return to the original state when these activities cease. The Navy has determined that only the use of sonar and other transducers and in-water detonations have the potential to affect marine mammals to a level that would constitute harassment under the MMPA. Stressor/resource interactions that were determined to have negligible or no impacts (i.e., vessel noise, aircraft noise, weapons noise, and explosions in air) are all sound sources other than sonar and other transducers and in-water detonations, as is consistent with previous rule-making pursuant to the MMPA (National Oceanic and Atmospheric Administration, 2015a).

Prey Distribution and Abundance. Fish and invertebrate (e.g., squid) marine mammal prey species are present in the Study Area. Fishes, like other vertebrates, have variety of different sensory systems to glean information from ocean around them (Astrup & Mohl, 1993; Astrup, 1999; Braun & Grande, 2008; Carroll et al., 2017; Hawkins & Johnstone, 1978; Ladich & Popper, 2004; Ladich & Schulz-Mirbach, 2016; Mann et al., 2001; Nedwell et al., 2004; Popper, 2003; Popper et al., 2005). Fish detect both pressure and particle motion (terrestrial vertebrates generally only detect pressure). Most marine fishes primarily detect particle motion using the inner ear and lateral line system, while some fishes possess additional morphological adaptations or specializations that can enhance their sensitivity to sound pressure, such as a gas-filled swim bladder (Braun & Grande, 2008; Popper & Fay, 2010).

Hearing capabilities vary considerably between different fish species, with data available for just over 100 species out of the 34,000 marine and freshwater fish species (Eschmeyer & Fong, 2017). In order to better understand acoustic impacts on fishes, fish hearing groups are defined by species that possess a similar continuum of anatomical features, which result in varying degrees of hearing sensitivity (Popper & Hastings, 2009). There are four hearing groups defined for all fish species (modified from Popper et al. (2014)) within this analysis. They include (1) fishes without a swim bladder (e.g., flatfish, sharks, rays,), (2) fishes with a swim bladder not involved in hearing (e.g., salmon, cod, pollock), (3) fishes with a swim bladder involved in hearing (e.g., sardines, anchovy, herring), and (4) fishes with a swim bladder involved in high-frequency hearing (e.g., shad and menhaden). Most fish species preyed upon by marine mammals would not be likely to perceive or hear Navy mid- or high-frequency sonars. While hearing studies have not been done on sardines and northern anchovies, it would not be unexpected for them to have hearing similarities to Pacific herring (up to 2–5 kHz) (Mann et al., 2005). Currently, less data are available to estimate the range of best sensitivity for fishes without a swim bladder.

In terms of physiology, multiple scientific studies have documented a lack of mortality or physiological effects to fish from exposure to low- and mid-frequency sonar and other sounds (Halvorsen et al., 2012; Jørgensen et al., 2005; Juanes et al., 2017; Kane et al., 2010; Kvadsheim & Sevaldsen, 2005; Popper et al., 2007; Popper & Hawkins, 2016; Watwood et al., 2016). Techer et al. (2017) exposed carp in floating cages for up to 30 days to low-power 23 and 46 kHz sources without any significant physiological response. Other studies have documented either a lack of TTS in species whose hearing range cannot perceive Navy sonar; or for those species that could perceive sonar-like signals, any TTS experienced would be recoverable (Halvorsen et al., 2012; Jørgensen et al., 2005; Juanes et al., 2017; Kane et al., 2010; Kvadsheim & Sevaldsen, 2005; Ladich & Fay, 2013; Popper et al., 2007; Popper & Hawkins, 2016; Smith, 2016; Watwood et al., 2016). Only fishes that have specializations that enable them to hear sounds above about 2,500 Hz (2.5 kHz) such as herring (Halvorsen et al., 2012; Mann et al., 2005; Popper

et al., 2014) would have the potential to receive TTS or exhibit behavioral responses from exposure to mid-frequency sonar. In addition, any sonar-induced TTS to fish whose hearing range could perceive sonar would only occur in the narrow spectrum of the source (e.g., 3.5 kHz) compared to the fish's total hearing range (e.g., 0.01 kHz to 5 kHz). Overall, Navy sonar sources are much narrower in terms of source frequency compared to a given fish species full hearing range (Halvorsen et al., 2012; Jørgensen et al., 2005; Juanes et al., 2017; Kane et al., 2010; Kvadsheim & Sevaldsen, 2005; Popper et al., 2007; Popper & Hawkins, 2016; Watwood et al., 2016).

In terms of behavioral responses, Juanes et al. (2017) discuss the potential for negative impacts from anthropogenic soundscapes on fish, but the author's focus was on broader-based sounds such as ship and boat noise sources. Watwood et al. (2016) also documented no behavioral responses by reef fish after exposure to mid-frequency active sonar. Doksaeter et al. (2009); Doksaeter et al. (2012) reported no behavioral responses to mid-frequency naval sonar by Atlantic herring—specifically, no escape reactions (vertically or horizontally) observed in free swimming herring exposed to mid-frequency sonar transmissions. Based on these results (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012a), Sivle et al. (2014) created a model in order to report on the possible population-level effects on Atlantic herring from active naval sonar. The authors concluded that the use of naval sonar poses little risk to populations of herring regardless of season, even when the herring populations are aggregated and directly exposed to sonar. Finally, Bruintjes et al. (2016) commented that fish exposed to any short-term noise within their hearing range might initially startle but would quickly return to normal behavior.

Occasional behavioral reactions to intermittent explosions and impulsive sound sources are unlikely to cause long-term consequences for individual fish or populations. Fish that experience hearing loss as a result of exposure to explosions and impulsive sound sources may have a reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. However, PTS has not been known to occur in fishes, and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2005; Popper et al., 2014; Smith et al., 2006). It is not known if damage to auditory nerve fibers could occur, and if so, whether fibers would recover during this process. It is also possible for fish to be injured or killed by an explosion in the immediate vicinity of the surface from dropped or fired ordnance, or near the bottom from shallow water bottom-placed underwater mine warfare detonations. Physical effects from pressure waves generated by underwater sounds (e.g., underwater explosions) could potentially affect fish within proximity of training or testing activities. The shock wave from an underwater explosion is lethal to fish at close range, causing massive organ and tissue damage and internal bleeding (Keevin & Hempen, 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors, including fish size, body shape, orientation, and species (Keevin & Hempen, 1997; Wright, 1982). 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 & Finneran, 2006; O'Keeffe, 1984; O'Keeffe & Young, 1984; Wiley et al., 1981; Yelverton et al., 1975). Species with gas-filled organs have a higher potential for mortality than those without them (Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994).

Fish not killed or driven from a location by an explosion might change their behavior, feeding pattern, or distribution. Changes in behavior of fish have been observed as a result of sound produced by explosives, with effect intensified in areas of hard substrate (Wright, 1982). However, Navy avoids hard substrate to the best extent practical during in-water detonations or surface detonations over deep

water. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

In conclusion, for fishes exposed to Navy sonar, there would be limited sonar use spread out in time and space across large offshore areas such that only small areas are actually ensonified (tens of miles) compared to the total life history distribution of fish prey species. There would be no probability for mortality and physical injury from sonar, and for most species, no or little potential for hearing or behavioral effects, except to a few select fishes with hearing specializations (e.g., herring) that could perceive mid-frequency sonar. Training and testing exercises involving explosions are dispersed in space and time; therefore, repeated exposure of individual fishes are unlikely. Mortality and injury effects to fishes from explosives would be localized around the area of a given in-water explosion, but only if individual fish and the explosive (and immediate pressure field) were co-located at the same time. Fishes deeper in the water column or on the bottom would not be affected by water surface explosions. Repeated exposure of individual fish to sound and energy from underwater explosions is not likely given fish movement patterns, especially schooling prey species. Most acoustic effects, if any, are expected to be short term and localized. Long-term consequences for fish populations, including key prey species within the Study Area, would not be expected.

Vessels and in-water devices do not normally collide with adult fish, most of which can detect and avoid them. Exposure of fishes to vessel strike stressors is limited to those fish groups that are large, slow-moving, and may occur near the surface, such as ocean sunfish, whale sharks, basking sharks, and manta rays, which are not marine mammal prey species. Vessel strikes would not pose a risk to most of the other marine fish groups, because many fish can detect and avoid vessel movements, making strikes rare and allowing the fish to return to their normal behavior after the ship or device passes. As a vessel approaches a fish, it could have a detectable behavioral or physiological response (e.g., swimming away and increased heart rate) as the passing vessel displaces it. However, such reactions are not expected to have lasting effects on the survival, growth, recruitment, or reproduction of these marine fish groups at the population level.

In addition to fish, prey sources such as marine invertebrates could potentially be impacted by sound stressors as a result of the proposed activities. Data on response of invertebrates such as squid has been documented (de Soto, 2016; Sole et al., 2017). Sole et al. (2017) reported physiological injuries to cuttlefish in cages placed at sea when exposed during a controlled exposure experiment to low-frequency sources (315 Hz, 139–142 dB re 1 μPa^2 and 400 Hz, 139–141 dB re 1 μPa^2). Fewtrell and McCauley (2012) reported squids maintained in cages displayed startle responses and behavioral changes when exposed to seismic air gun sonar (136–162 re 1 $\mu Pa^2 \cdot s$). However, the sources Sole et al. (2017) and Fewtrell and McCauley (2012) used are not similar and are much lower frequency than typical Navy sources or those included in the proposed action within the Study Area. Nor do the studies address the issue of individual displacement outside of a zone of impact when exposed to sound. Squids, like most fish species, are likely more sensitive to low-frequency sounds, and may not perceive mid- and high-frequency sonars such as Navy sonars. Like fish, cumulatively individual and population-level impacts from exposure to Navy sonar and explosives for squid are not likely to be significant, and explosive impacts would be short term, localized and would likely be inconsequential to invertebrate populations. Explosions could kill or injure nearby marine invertebrates. Vessels also have the potential to impact marine invertebrates by disturbing the water column or sediments, or directly striking organisms (Bishop, 2008). The propeller wash (water displaced by propellers used for propulsion) from vessel movement and water displaced from vessel hulls can potentially disturb marine invertebrates in

the water column and is a likely cause of zooplankton mortality (Bickel et al., 2011). The localized and short-term exposure to explosions or vessels could displace, injure, or kill zooplankton, invertebrate eggs or larvae, and macro-invertebrates. However, mortality or long-term consequences for a few animals is unlikely to have measurable effects on overall stocks or populations. Long-term consequences to marine invertebrate populations would not be expected as a result of exposure to sounds or vessels in the Study Area.

Military expended materials resulting from training and testing could potentially result in minor long-term changes to benthic habitat. Military expended materials may be colonized over time by benthic organisms that prefer hard substrate and would provide structure that could attract some species of fish or invertebrates. Overall, the combined impacts of sound exposure, explosions, vessel strikes, and military expended materials resulting from the proposed activities would not be expected to have measurable effects on populations of marine mammal prey species.

Overall, the combined impacts of the Proposed Action would not be expected to have measurable effects on populations of marine mammal prey species and marine mammal habitat.

10 Anticipated Effects of Habitat Impacts on Marine Mammals

The proposed training and testing events for the NWTT Study Area are not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations. Based on the discussions in Chapter 9 (Anticipated Impacts on Habitat), there will be no impacts on marine mammals resulting from loss or modification of marine mammal habitat.

11 Mitigation Measures

The Navy will continue to implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors. As applicable to marine mammals, the Navy's mitigation measures are organized into two categories: procedural mitigation and mitigation areas. A more detailed and complete discussion of the evaluation process used to develop, assess, and select mitigation measures can be found in Chapter 5 (Mitigation) of the NWTT Draft Supplemental EIS/OEIS.

The mitigation measures are designed to achieve one or more benefits, such as the following:

- Effect the least practicable adverse impact on marine mammal species or stocks and their habitat and have a negligible impact on marine mammal species and stocks (as required under the MMPA)
- Ensure that the Proposed Action does not jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of critical habitat (as required under the ESA)
- Avoid or minimize adverse effects on essential fish habitat (as required under the Magnuson-Stevens Fishery Conservation and Management Act)

The following sections summarize the mitigation measures that will be implemented in association with the training and testing activities analyzed in this document. Navy operators, environmental planners, and scientific experts developed mitigation that is likely to be effective at avoiding or reducing impacts on marine mammals, and that is practical to implement by the definitions provided in Section 5.2.3 (Practicality of Implementation) of the NWTT Draft Supplemental EIS/OEIS. For some activities, the Navy also implements mitigation for other species or resources, such as sea turtles and birds, as detailed in Chapter 5 (Mitigation) of the NWTT Draft Supplemental EIS/OEIS.

11.1 Procedural Mitigation

The first procedural mitigation (Table 11-1) is designed to aid Lookouts and other personnel with the observation and environmental compliance responsibilities that are outlined in the remainder of this section, as well as training and testing activity reporting requirements. The remainder of the procedural mitigation measures are organized by stressor type and activity category.

Table 11-1: Procedural Mitigation for Environmental Awareness and Education

Procedural Mitigation Description
Stressor or Activity • All training and testing activities, as applicable
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: – **Introduction to the U.S. Navy Afloat Environmental Compliance Training Series.** The introductory module provides information on environmental laws (e.g., ESA, MMPA) and the corresponding responsibilities that are relevant to Navy training and testing activities. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship. – **Marine Species Awareness Training.** All bridge watch personnel, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare and mine warfare rotary-wing aircrews, Lookouts, and equivalent civilian personnel must successfully complete the Marine Species Awareness Training prior to standing watch or serving as a Lookout. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures. Navy biologists developed Marine Species Awareness Training to improve the effectiveness of visual observations for biological resources, focusing on marine mammals and sea turtles, and including floating vegetation, jellyfish aggregations, and flocks of seabirds. – **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. – **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.

11.1.1 ACOUSTIC STRESSORS

Mitigation measures for acoustic stressors are provided in Table 11-2 and Table 11-3.

Table 11-2: Procedural Mitigation for Active Sonar

Procedural Mitigation Description
Stressor or Activity • Low-frequency active sonar, mid-frequency active sonar, high-frequency active sonar – 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). – 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).
Number of Lookouts and Observation Platform • Hull-mounted sources: – 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) – 2 Lookouts: Platforms without space or manning restrictions while underway (at the forward part of the ship) • Sources that are not hull-mounted: – 1 Lookout on the ship or aircraft conducting the activity
Mitigation Requirements • Mitigation zones: – 1,000 yd. power down, 500 yd. power down, and 200 yd. or 100 yd. shut down for low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar – 200 yd. or 100 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 floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; 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; power down active sonar transmission by 6 dB if a marine mammal is observed within 1,000 yd. of the sonar source; power down an additional 4 dB (10 dB total) if a marine mammal is observed within 500 yd.; cease transmission if a cetacean or pinniped in the NWTT Offshore Area or Western Behm Canal is observed within 200 yd.; cease transmission if a pinniped in NWTT Inland Waters is observed within 100 yd. (except if hauled out on, or in the water near, man-made structures and vessels). – 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; cease transmission if a cetacean or pinniped in the NWTT Offshore Area or Western Behm Canal is observed within 200 yd. of the sonar source; cease transmission if a pinniped in NWTT Inland Waters is observed within 100 yd. (except if hauled out on, or in the water near, man-made structures and vessels). • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing or powering up active sonar transmission) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonar source; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-deployed sonar sources or 30 minutes for vessel-deployed sonar sources; (4) for mobile activities, the active sonar source has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting; or (5) for activities using hull-mounted sonar, the Lookout 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).

Table 11-3: Procedural Mitigation for Weapons Firing Noise

Procedural Mitigation Description
Stressor or Activity • Weapons firing noise associated with large-caliber gunnery activities
Number of Lookouts and Observation Platform • 1 Lookout positioned on the ship conducting the firing Depending on the activity, the Lookout could be the same one described in Table 11-6 for Explosive Medium-Caliber and Large-Caliber Projectiles or – Table 11-13 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 floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of weapons firing. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease weapons firing. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing weapons firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the firing ship; (3) the mitigation zone has been clear from any additional sightings for 30 minutes; or (4) for mobile activities, the firing ship has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

11.1.2 EXPLOSIVE STRESSORS

Mitigation measures for explosives are provided in Table 11-4 through Table 11-10.

Table 11-4: Procedural Mitigation for Explosive Sonobuoys

Procedural Mitigation Description
Stressor or Activity • Explosive sonobuoys
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 marine mammals 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 field, which typically lasts 20–30 minutes): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. – Visually observe the mitigation zone for marine mammals; if observed, relocate or delay the start of sonobuoy or source/receiver pair detonations. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease sonobuoy or source/receiver pair detonations. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonobuoy; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (e.g., prior to maneuvering off station): – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals in the vicinity of where detonations occurred; if any injured or dead marine mammals 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.

Table 11-5: Procedural Mitigation for Explosive Torpedoes

Procedural Mitigation Description
Stressor or Activity • Explosive torpedoes
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 marine mammals while performing their regular duties.
Mitigation Requirements • Mitigation zone: – 2,100 yd. around the intended impact location • Prior to the initial start of the activity (e.g., during deployment of the target): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. – Visually observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (e.g., prior to maneuvering off station): – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals in the vicinity of where detonations occurred; if any injured or dead marine mammals 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.

Table 11-6: 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 – Mitigation applies to activities using a surface target
Number of Lookouts and Observation Platform • 1 Lookout on the vessel conducting the activity – For activities using explosive large-caliber projectiles, depending on the activity, the Lookout could be the same as the one described in Table 11-3 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 marine mammals while performing their regular duties.
Mitigation Requirements • Mitigation zones: – 600 yd. around the intended impact location for explosive medium-caliber projectiles – 1,000 yd. around the intended impact location for explosive large-caliber projectiles • Prior to the initial start of the activity (e.g., when maneuvering on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal 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 30 minutes for vessel-based firing; or (4) for activities using mobile targets, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • After completion of the activity (e.g., prior to maneuvering off station): – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals in the vicinity of where detonations occurred; if any injured or dead marine mammals 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.

Table 11-7: Procedural Mitigation for Explosive Missiles

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed explosive missiles – Mitigation applies to activities using a surface target
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 marine mammals while performing their regular duties.
Mitigation Requirements • Mitigation zone: – 2,000 yd. around the intended impact location • Prior to the initial start of the activity (e.g., during a fly-over of the mitigation zone): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (e.g., prior to maneuvering off station): – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals in the vicinity of where detonations occurred; if any injured or dead marine mammals 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.

Table 11-8: Procedural Mitigation for Explosive Bombs

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
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 marine mammals 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 floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; 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; if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target; (3) the mitigation zone has been clear from any additional sightings for 10 minutes; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • After completion of the activity (e.g., prior to maneuvering off station): – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals in the vicinity of where detonations occurred; if any injured or dead marine mammals 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.

Table 11-9: Procedural Mitigation for Explosive Mine Countermeasure and Neutralization Activities

Procedural Mitigation Description
Stressor or Activity • Explosive mine countermeasure and neutralization activities
Number of Lookouts and Observation Platform • 1 Lookout positioned on a vessel or in an aircraft when implementing the smaller mitigation zone • 2 Lookouts (one positioned in an aircraft and one on a small boat) when implementing the larger mitigation zone • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for marine mammals while performing their regular duties.
Mitigation Requirements • Mitigation zones: – 600 yd. around the detonation site for activities using ≤ 5 lb. net explosive weight – 2,100 yd. around the detonation site for activities using > 5–60 lb. net explosive weight • Prior to the initial start of the activity (e.g., when maneuvering on station; typically, 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of detonations. • During the activity: – Observe for marine mammals; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to detonation site; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (typically 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained): – Observe for marine mammals in the vicinity of where detonations occurred; if any injured or dead marine mammals 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.

Table 11-10: Procedural Mitigation for Explosive Mine Neutralization Activities Involving Navy Divers

Procedural Mitigation Description
Stressor or Activity • Explosive mine neutralization activities involving Navy divers
Number of Lookouts and Observation Platform • 2 Lookouts on two small boats with one Lookout each, one of which will be a Navy biologist • All divers placing the charges on mines will support the Lookouts while performing their regular duties and will report applicable sightings to the lead Lookout, the supporting small boat, or the 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 marine mammals while performing their regular duties.
Mitigation Requirements • Mitigation zone: – 500 yd. around the detonation site during activities using > 0.5–2.5 lb. net explosive weight • Prior to the initial start of the activity (starting 30 minutes before the first planned detonation): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of detonations. – The Navy will ensure the area is clear of marine mammals for 30 minutes prior to commencing a detonation. – A Navy biologist will serve as the lead Lookout and will make the final determination that the mitigation zone is clear of any biological resource sightings prior to the commencement of a detonation. The Navy biologist will maintain radio communication with the unit conducting the event and the other Lookout. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease detonations. – 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, 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. – The Navy will use only positively controlled charges (i.e., no time-delay fuses). – The Navy will use the smallest practicable charge size for each activity. – Activities will be conducted in Beaufort sea state number 2 conditions or better and will not be conducted in low visibility conditions. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the detonation site; or (3) the mitigation zone has been clear from any additional sightings for 30 minutes. • After each detonation and the completion of an activity (for 30 minutes): – Observe for marine mammals in the vicinity of where detonations occurred and immediately downstream of the detonation location; if any injured or dead marine mammals are observed, follow established incident reporting procedures.

Procedural Mitigation Description
– If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred. • Additional requirements: – At the Hood Canal Explosive Ordnance Disposal Range and Crescent Harbor Explosive Ordnance Disposal Range, naval units will obtain permission from the appropriate designated Command authority prior to conducting explosive mine neutralization activities involving the use of Navy divers. – At the Hood Canal Explosive Ordnance Disposal Range, during February, March, and April (the juvenile migration period for Hood Canal summer-run chum), the Navy will not use > 0.5–2.5 lb. net explosive weight detonations. – At the Hood Canal Explosive Ordnance Disposal Range, during August, September, and October (the adult migration period for Hood Canal summer-run chum and Puget Sound Chinook), the Navy will avoid using > 0.5–2.5 lb. net explosive weight detonations to the maximum extent practicable unless necessitated by mission requirements. – At the Crescent Harbor Explosive Ordnance Disposal Range, the Navy will conduct explosive activities at least 1,000 m from the closest point of land to avoid or reduce impacts on fish (e.g., bull trout) in nearshore habitat areas.

11.1.3 Physical Disturbance and Strike Stressors

Mitigation measures for physical disturbance and strike stressors are provided in Table 11-11 through

Table 11-15.

Table 11-11: Procedural Mitigation for Vessel Movement

Procedural Mitigation Description
Stressor or Activity • Vessel movement – The mitigation will not be applied if: (1) the vessel's safety is threatened, (2) the vessel is restricted in its ability to maneuver (e.g., during launching and recovery of aircraft or landing craft, during towing activities, when mooring, during Transit Protection Program exercises or other events involving escort vessels), (3) the vessel is operated autonomously, or (4) when impractical based on mission requirements (e.g., during test body retrieval by range craft).
Number of Lookouts and Observation Platform • 1 Lookout on the vessel that is underway
Mitigation Requirements • Mitigation zones: – 500 yd. (for surface ships) around whales – 200 yd. (for surface ships) around other marine mammals (except bow-riding dolphins and pinnipeds hauled out man-made navigational structures, port structures, and vessels) – 100 yd. (for small boats, such as range craft) around marine mammals (except bow-riding dolphins and pinnipeds hauled out man-made navigational structures, port structures, and vessels) • During the activity: – When underway, observe the mitigation zone for marine mammals; if observed, maneuver to maintain distance. • Additional requirements: – Prior to Small Boat Attack exercises at Naval Station Everett, Naval Base Kitsap Bangor, or Naval Base Kitsap Bremerton, Navy event planners will coordinate with Navy biologists during the event planning process. Navy biologists will work with NMFS to determine the likelihood of marine mammal presence in the planned training location. Navy biologists will notify event planners of the likelihood of species presence as they plan specific details of the event (e.g., timing, location, duration). The Navy will provide additional environmental awareness training to event participants. The training will alert participating ship and aircraft crews to the possible presence of marine mammals in the training location. Lookouts will use the information to assist their visual observation of applicable mitigation zones and to aid in the implementation of procedural mitigation. – If a marine mammal vessel strike occurs, the Navy will follow the established incident reporting procedures.

Table 11-12: Procedural Mitigation for Towed In-Water Devices

Procedural Mitigation Description
Stressor or Activity • Towed in-water devices – Mitigation applies to devices towed from a manned surface platform or manned aircraft, or when a manned support craft is already participating in an activity involving in-water devices being towed by unmanned platforms. – The mitigation will not be applied if the safety of the towing platform or in-water device is threatened.

Procedural Mitigation Description
Number of Lookouts and Observation Platform • 1 Lookout positioned on the towing platform or support craft
Mitigation Requirements • Mitigation zones: – 250 yd. (for in-water devices towed by aircraft or surface ships) around marine mammals (except bow-riding dolphins and pinnipeds hauled out on man-made navigational structures, port structures, and vessels) – 100 yd. (for in-water devices towed by small boats, such as range craft) around marine mammals (except bow-riding dolphins and pinnipeds hauled out on man-made navigational structures, port structures, and vessels) • During the activity (i.e., when towing an in-water device) – Observe the mitigation zone for marine mammals; if observed, maneuver to maintain distance.

Table 11-13: 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 – Mitigation applies to activities using a surface target
Number of Lookouts and Observation Platform • 1 Lookout positioned on the platform conducting the activity • Depending on the activity, the Lookout could be the same as the one described in Table 11-3 for Weapons Firing Noise.
Mitigation Requirements • Mitigation zone: – 200 yd. around the intended impact location • Prior to the initial start of the activity (e.g., when maneuvering on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal sighting before or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-based firing or 30 minutes for vessel-based firing; or (4) for activities using a mobile target, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

Table 11-14: Procedural Mitigation for Non-Explosive Missiles

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed non-explosive missiles – Mitigation applies to activities using a surface target
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: – 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): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal sighting prior to or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained.

Table 11-15: 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
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: – 1,000 yd. around the intended target • Prior to the initial start of the activity (e.g., when arriving on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of bomb deployment or mine laying. • During the activity (e.g., during approach of the target or intended minefield location): – Observe the mitigation zone for marine mammals; if observed, cease bomb deployment or mine laying. • Commencement/recommencement conditions after a marine mammal sighting prior to or during the activity: – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment or mine laying) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target or minefield location; (3) the mitigation zone has been clear from any additional sightings for 10 minutes; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

11.2 MITIGATION AREAS

The Navy conducted a biological assessment and operational analysis of potential mitigation areas for marine mammals, which is detailed in Appendix K (Geographic Mitigation Assessment) of the NWTT Draft Supplemental EIS/OEIS. The appendix includes background information and details for each of the areas considered, and includes analyses of areas identified during the NEPA scoping process. The Navy will finalize its mitigation areas during the consultation and permitting processes.

The Navy considered the potential for a mitigation area to be effective if it met the following criteria:

- **The mitigation area is a key area of biological importance to marine mammals**: The best available science suggests that the mitigation area is important to one or more species or resources for a biologically important life process (i.e., foraging, migration, reproduction); and
- **The mitigation would result in an avoidance or reduction of impacts**: Implementing the mitigation would likely result in an avoidance or reduction of impacts on species, stocks, or populations of marine mammals based on data regarding their seasonality, density, and

behavior. Furthermore, implementing the mitigation will not shift or transfer adverse effects from one species to another (e.g., to a more vulnerable or sensitive species).

The benefits of mitigation areas are considered qualitatively and are not factored into the quantitative analysis process or reductions in take for MMPA and ESA impact estimates. In Appendix K (Geographic Mitigation Assessment) of the NWTT Draft Supplemental EIS/OEIS, potential geographic mitigation area benefits are discussed in terms of the context of impact avoidance or reduction.

During its assessment to determine how and to what degree the implementation of mitigation would be compatible with meeting the purpose and need of the Proposed Action, the Navy considered a mitigation measure to be practical to implement if it met all criteria listed below:

- **Implementing the mitigation is safe**: Mitigation measures must not increase safety risks to Navy personnel and equipment, or to the public. When assessing whether implementing a mitigation measure would be safe, the Navy factored in the potential for increased pilot fatigue; accelerated fatigue-life of aircraft; typical fuel restrictions of participating aircraft; locations of refueling stations; proximity to aircraft emergency landing fields, critical medical facilities, and search and rescue capabilities; space restrictions of the observation platforms; the ability to de-conflict platforms and activities to ensure that training and testing activities do not impact each other; and the ability to avoid interaction with non-Navy sea space and airspace uses, such as established commercial air traffic routes, commercial vessel shipping lanes, and areas used for energy exploration or alternative energy development. Other safety considerations included identifying if mitigation measures would reasonably allow Lookouts to safely and effectively maintain situational awareness while observing the mitigation zones during typical activity conditions, or if the mitigation would increase the safety risk for personnel. For example, the safety risk would increase if Lookouts were required to direct their attention away from essential mission requirements.
- **Implementing the mitigation is sustainable**: One of the primary factors that the Navy incorporates into the planning and scheduling of its training and testing activities is the amount and type of available resources, such as funding, personnel, and equipment. Mitigation measures must be sustainable over the life of the Proposed Action, meaning that they will not require the use of resources in excess of what is available. When assessing whether implementing a mitigation measure would be sustainable, the Navy considered if the measure would require excessive time on station or time away from homeport for Navy personnel, require the use of additional personnel (i.e., manpower) or equipment (e.g., adding a small boat to serve as an additional observation platform), or result in additional operational costs (e.g., increased fuel consumption, equipment maintenance, or acquisition of new equipment).
- **Implementing the mitigation allows the Navy to continue meeting its mission requirements**: The Navy considered if each individual measure and the iterative and cumulative impact of all potential measures would be within the Navy's legal authority to implement. The Navy also considered if mitigation would modify training or testing activities in a way that would prevent individual activities from meeting their mission objectives and if mitigation would prevent the Navy from meeting its national security requirements or statutorily-mandated Title 10 requirements, such as by:

  - Impacting training and testing realism or preventing ready access to ranges, operating areas, facilities, or range support structures (which would reduce realism and present sea space and airspace conflicts).

- Impacting the ability of Sailors to train and become proficient in using sensors and weapon systems as would be required in areas analogous to where the military operates or causing an erosion of capabilities or reduction in perishable skills (which would result in a significant risk to personnel or equipment safety during military missions and combat operations).
- Impacting the ability of units to meet their individual training and certification requirements (which would impact the ability to deploy with the required level of readiness necessary to accomplish any tasking by Combatant Commanders).
- Impacting the ability to certify forces to deploy to meet national security tasking (which would limit the flexibility of Combatant Commanders and warfighters to project power, engage in multi-national operations, and conduct the full range of naval warfighting capabilities in support of national security interests).
- Impacting the ability of researchers, program managers, and weapons system acquisition programs to conduct accurate acoustic research to meet research objectives, effectively test systems and platforms (and components of these systems and platforms) before full-scale production or delivery to the fleet, or complete shipboard maintenance, repairs, or pierside testing prior to at-sea operations (which would not allow the Navy to ensure safety, functionality, and accuracy in military mission and combat conditions per required acquisition milestones or on an as-needed basis to meet operational requirements).
- Requiring the Navy to provide advance notification of specific times and locations of Navy platforms, such as platforms using active sonar (which would present national security concerns).
- Reducing the Navy's ability to be ready, maintain deployment schedules, or respond to national emergencies or emerging national security challenges (which would present national security concerns).

Based on the analysis presented in Appendix K (Geographic Mitigation Assessment) of the NWTT Draft Supplemental EIS/OEIS, the Navy is proposing to implement mitigation measures to avoid or reduce impacts on marine mammals within the following mitigation areas, as provided in

Table 11-16 and shown in

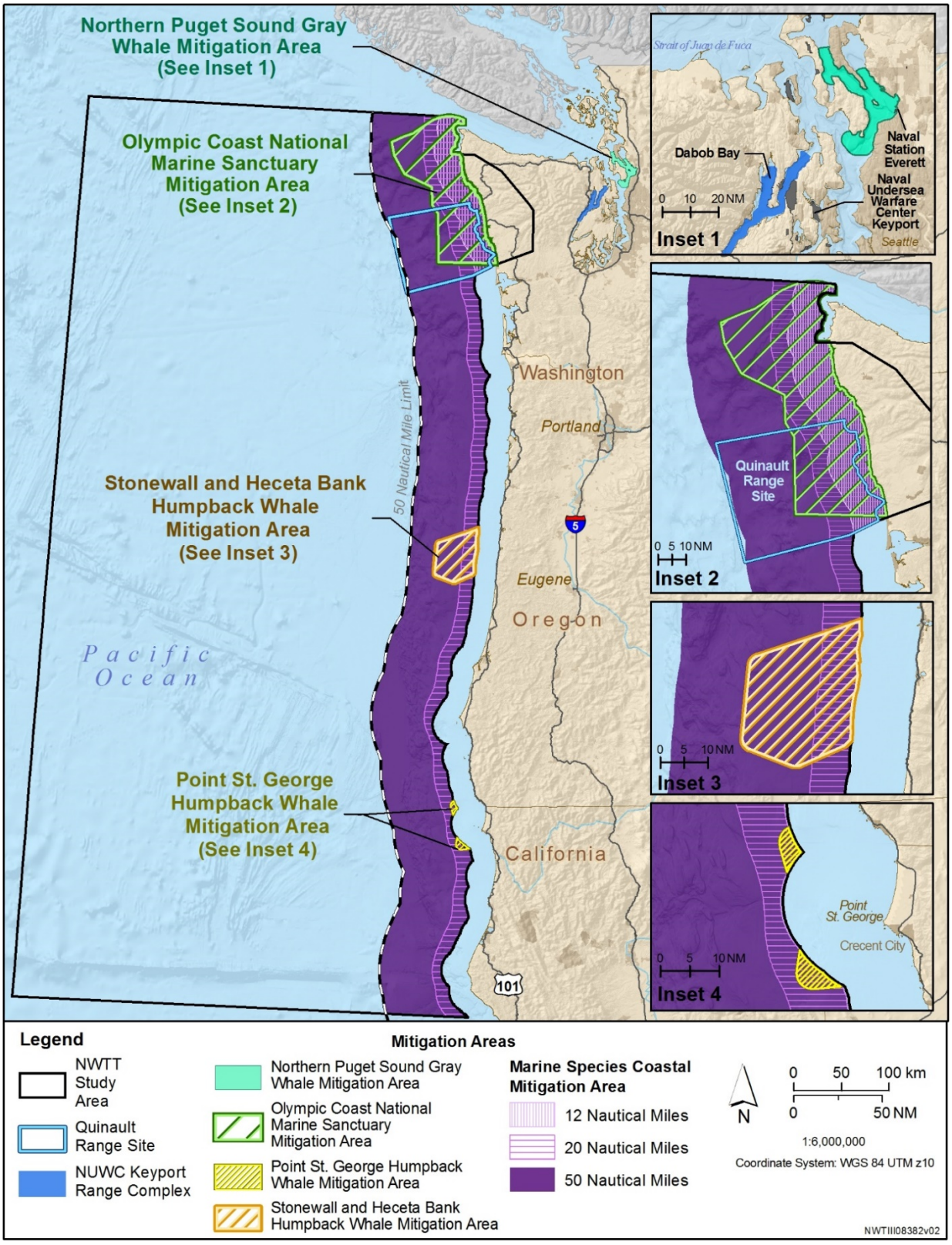

Northern Puget Sound Gray Whale Mitigation Area (See Inset 1)
Olympic Coast National Marine Sanctuary Mitigation Area (See Inset 2)
Stonewall and Heceta Bank Humpback Whale Mitigation Area (See Inset 3)
Point St. George Humpback Whale Mitigation Area (See Inset 4)
50 Nautical Mile Limit
Washington
Portland
Eugene
Oregon
California
Pacific Ocean
101
5
Strait of Juan de Fuca
Dabob Bay
Naval Station Everett
Naval Undersea Warfare Center Keyport
Seattle
0 10 20 NM
Inset 1
Quinault Range Site
0 5 10 NM
Inset 2
0 5 10 NM
Inset 3
Point St. George
Crescent City
0 5 10 NM
Inset 4
Legend
NWTT Study Area
Quinault Range Site
NUWC Keyport Range Complex
Mitigation Areas
Northern Puget Sound Gray Whale Mitigation Area
Olympic Coast National Marine Sanctuary Mitigation Area
Point St. George Humpback Whale Mitigation Area
Stonewall and Heceta Bank Humpback Whale Mitigation Area
Marine Species Coastal Mitigation Area
12 Nautical Miles
20 Nautical Miles
50 Nautical Miles
N
0 50 100 km
0 50 NM
1:6,000,000
Coordinate System: WGS 84 UTM z10
NWTIII08382v02

Figure 11-1.

Table 11-16: Mitigation Areas in the NWTT Study Area

Mitigation Area Description
Stressor or Activity • Sonar • Explosives • Physical disturbance and strikes
Mitigation Requirements • **Marine Species Coastal Mitigation Area (year-round)** – Within 50 NM from shore in the Marine Species Coastal Mitigation Area, the Navy will not conduct: (1) explosive training activities, (2) explosive testing activities (with the exception of explosive Mine Countermeasure and Neutralization Testing activities), (3) non-explosive missile training activities, and (4) non-explosive torpedo training activities. Should national security present a requirement to conduct these activities in the 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. – Within 20 NM from shore in the Marine Species Coastal Mitigation Area, the Navy will not conduct non-explosive large-caliber gunnery training activities and non-explosive bombing training activities. Should national security present a requirement to conduct these activities in the 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. – Within 12 NM from shore in the Marine Species Coastal Mitigation Area, the Navy will not conduct non-explosive small- and medium-caliber gunnery training activities and Anti-Submarine Warfare Tracking Exercise – Helicopter, Maritime Patrol Aircraft, Ship, or Submarine training activities. Should national security present a requirement to conduct these activities in the 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. • **Olympic Coast National Marine Sanctuary Mitigation Area (year-round)** – Within the Olympic Coast National Marine Sanctuary Mitigation Area, the Navy will not conduct more than 32 hours of MF1 mid-frequency active sonar during training annually and will not conduct non-explosive bombing training activities. Should national security present a requirement to conduct more than 32 hours of MF1 mid-frequency active sonar during training annually or conduct non-explosive bombing training activities in the 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. – Within the Olympic Coast National Marine Sanctuary Mitigation Area, the Navy will not conduct more than 33 hours of MF1 mid-frequency active sonar during testing annually (except within the portion of the mitigation area that overlaps the Quinault Range Site) and will not conduct explosive Mine Countermeasure and Neutralization Testing activities. Should national security present a requirement for the Navy to conduct more than 33 hours of MF1 mid-frequency active sonar during testing annually (except within the portion of the mitigation area that overlaps the Quinault Range Site) or conduct explosive Mine Countermeasure and Neutralization Testing activities in the 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. • **Stonewall and Heceta Bank Humpback Whale Mitigation Area (May – November)** – Within the Stonewall and Heceta Bank Humpback Whale Mitigation Area, the Navy will not use MF1 mid-frequency active sonar or explosives during training and testing from May to November. Should national security present a requirement to use MF1 mid-frequency active sonar or explosives during training and testing from May to November, 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.

Table 11-16: Mitigation Areas in the NWTT Study Area (continued)

Mitigation Area Description
• **Point St. George Humpback Whale Mitigation Area (July – November)** – Within the Point St. George Humpback Whale Mitigation Area, the Navy will not use MF1 mid-frequency active sonar or explosives during training and testing from July to November. Should national security present a requirement to use MF1 mid-frequency active sonar or explosives during training and testing from July to November, 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. • **Puget Sound and Strait of Juan de Fuca Mitigation Area (year-round)** – Within the Puget Sound and Strait of Juan de Fuca Mitigation Area, the Navy will require units to obtain approval from the appropriate designated Command authority prior to: (1) the use of hull-mounted mid-frequency active sonar during training while underway, and (2) conducting ship and submarine active sonar pierside maintenance or testing. – Within the Puget Sound and Strait of Juan de Fuca Mitigation Area for Civilian Port Defense – Homeland Security Anti-Terrorism/Force Protection Exercises, Navy event planners will coordinate with Navy biologists during the event planning process. Navy biologists will work with NMFS to determine the likelihood of gray whale and Southern Resident Killer Whale presence in the planned training location. Navy biologists will notify event planners of the likelihood of species presence as they plan specific details of the event (e.g., timing, location, duration). The Navy will ensure environmental awareness of event participants. Environmental awareness will help alert participating ship and aircraft crews to the possible presence of marine mammals in the training location, such as gray whales and Southern Resident Killer Whales. • **Northern Puget Sound Gray Whale Mitigation Area (March – May)** – Within the Northern Puget Sound Gray Whale Mitigation Area, the Navy will not conduct Civilian Port Defense – Homeland Security Anti-Terrorism/Force Protection Exercises from March to May. Should national security present a requirement to conduct Civilian Port Defense – Homeland Security Anti-Terrorism/Force Protection Exercises from March to May, 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.

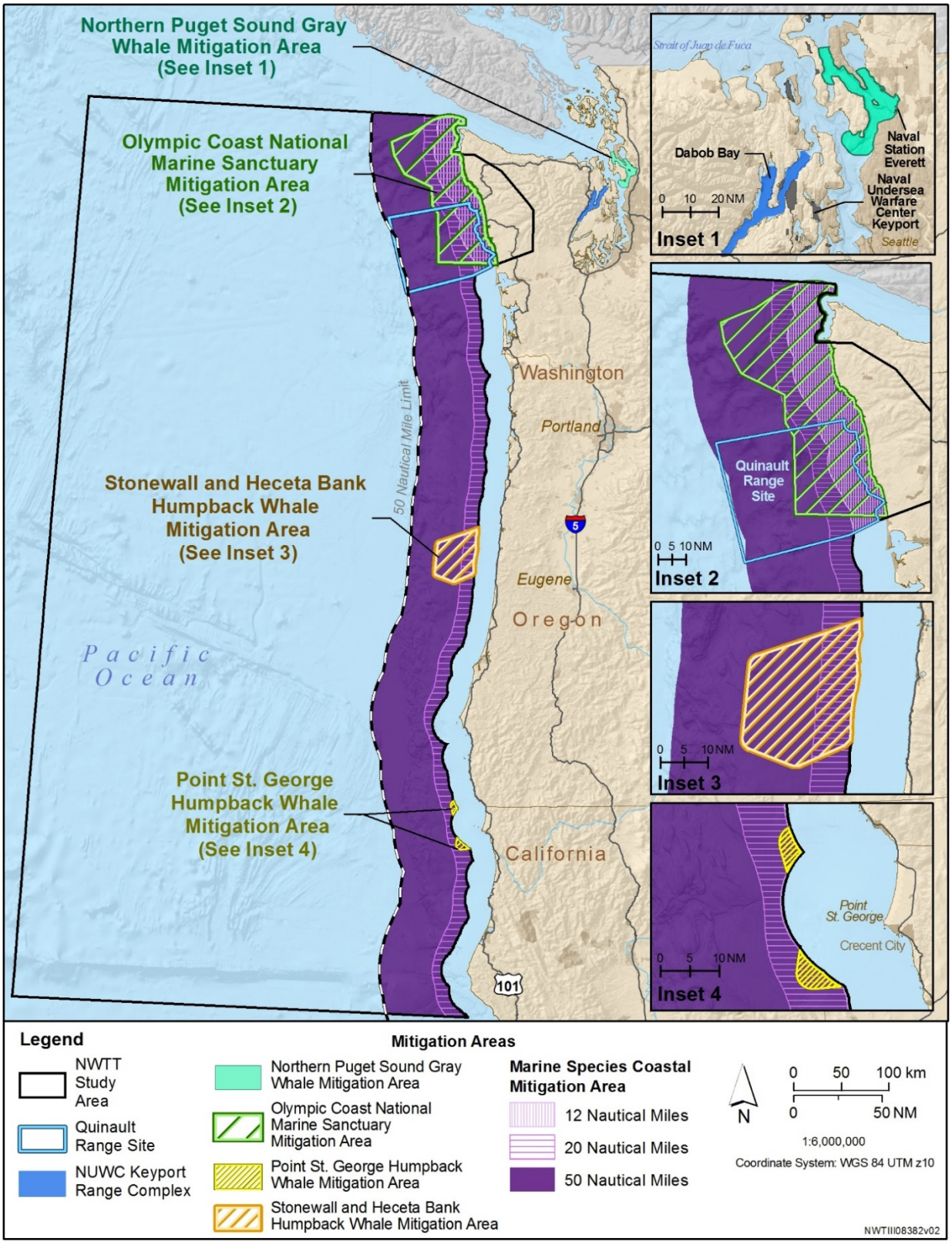


Figure 11-1: All Mitigation Areas in the Study Area

11.3 MITIGATION SUMMARY

The Navy's procedural mitigation measures for marine mammals are summarized in Table 11-17.

Table 11-17: Summary of Procedural Mitigation for Marine Mammals

Stressor or Activity	***Mitigation Zone Sizes and Other Requirements***
Environmental Awareness and Education	• Afloat Environmental Compliance Training program for applicable personnel
Active Sonar	• 2 Lookouts (hull-mounted sources on platforms without space or manning restrictions while underway) • 1 Lookout (all other sources) • Mitigation zones: – 1,000 yd. power down, 500 yd. power down, and 200 yd. or 100 yd. shut down for low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar (with exceptions for pinnipeds hauled out on, or in the water near, man-made structures and vessels) – 200 yd. or 100 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 (with exceptions for pinnipeds hauled out on, or in the water near, man-made structures and vessels)
Weapons Firing Noise	• 1 Lookout • Mitigation zone: 30° on either side of the firing line out to 70 yd. from the muzzle of weapon being fired
Explosive Sonobuoys	• 1 Lookout • Mitigation zone: 600 yd.
Explosive Torpedoes	• 1 Lookout • Mitigation zone: 2,100 yd.
Explosive Medium-Caliber and Large-Caliber Projectiles	• 1 Lookout • Mitigation zones: – 600 yd. for medium-caliber projectiles – 1,000 yd. for large-caliber projectiles
Explosive Missiles	• 1 Lookout • Mitigation zone: 2,000 yd.
Explosive Bombs	• 1 Lookout • Mitigation zone: 2,500 yd.
Explosive Mine Countermeasure and	• 1 Lookout (≤ 5 lb. charge) • 2 Lookouts (> 5–60 lb. charge)

Stressor or Activity	***Mitigation Zone Sizes and Other Requirements***
Neutralization Activities	• Mitigation zones: – 600 yd. (≤ 5 lb. charge) – 2,100 yd. (> 5–60 lb. charge)
Explosive Mine Neutralization Activities Involving Navy Divers	• 2 Lookouts, including 1 Navy biologist • Mitigation zone: – 500 yd. for > 0.5–2.5 lb. charges • Special pre- and post-event observations • Use of smallest practicable positive control charges • Requirements for low sea state (Beaufort 2 or less) and good visibility conditions • Permission required from the appropriate designated Command authority prior to explosive activities • At the Hood Canal Explosive Ordnance Disposal Range: no use of > 0.5–2.5 lb. charge during February, March, and April; avoidance of > 0.5–2.5 lb. charges to the maximum extent practicable during August, September, and October • At the Crescent Harbor Explosive Ordnance Disposal Range, no explosive activities at least 1,000 m from the closest point of land
Vessel Movement	• 1 Lookout • Mitigation zones: – 500 yd. (for surface ships) around whales – 200 yd. (for surface ships) around other marine mammals (except bow-riding dolphins and pinnipeds hauled out man-made navigational structures, port structures, and vessels) – 100 yd. (for small boats, such as range craft) around marine mammals (except bow-riding dolphins and pinnipeds hauled out man-made navigational structures, port structures, and vessels) • Special event planning and environmental training measures prior to Small Boat Attack Exercises
Towed In-Water Devices	• 1 Lookout • Mitigation zones: – 250 yd. (for in-water devices towed by aircraft or surface ships) around marine mammals (except bow-riding dolphins and pinnipeds hauled out on man-made navigational structures, port structures, and vessels) – 100 yd. (for in-water devices towed by small boats, such as range craft) around marine mammals (except bow-riding dolphins and pinnipeds hauled out on man-made navigational structures, port structures, and vessels)
Small-, Medium-, and Large-Caliber Non-Explosive	• 1 Lookout • Mitigation zone: 200 yd. during small-, medium-, and large-caliber events

Stressor or Activity	***Mitigation Zone Sizes and Other Requirements***
Practice Munitions	
Non-Explosive Missiles	• 1 Lookout • Mitigation zone: 900 yd.
Non-Explosive Bombs and Mine Shapes	• 1 Lookout • Mitigation zone: 1,000 yd.

12 Arctic Plan of Cooperation

Subsistence use is the traditional exploitation of marine mammals by native peoples (i.e., for their own consumption). In terms of this Request for LOAs, none of the proposed training or testing activities in the Study Area occurs in or near the Arctic. Based on the Navy discussions and conclusions in Chapter 7 (Anticipated Impact of the Activity) and Chapter 8 (Anticipated Impacts on Subsistence Uses), there are no anticipated impacts on any species or stocks migrating through the Study Area that might impact their availability for subsistence use.

13 Monitoring and Reporting

The Navy has been conducting marine species research and monitoring for over 20 years in areas where the Navy has been training and testing. The Navy developed a formal marine species monitoring program in support of the MMPA and ESA authorizations in 2009. This robust program has resulted in hundreds of technical reports and publications on marine mammals that have informed Navy and NMFS analysis in environmental planning documents, Rules, and Biological Opinions. The reports are made available to the public on the Navy's marine species monitoring website (https://www.navymarinespeciesmonitoring.us) and the data on the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (http://www.seamap.env.duke.edu).

The Navy commits to continue monitoring the occurrence, exposure, response, and consequences of marine species to Navy training and testing and to further research the effectiveness of implemented mitigation measures. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible.

Consistent with the cooperating agency agreement with NMFS, monitoring measures presented here, as well as mitigation measures discussed in Chapter 11 (Mitigation Measures), focus on the requirements for protection and management of marine resources. A well-designed monitoring program can provide important feedback for validating assumptions made in analyses and allow for adaptive management of marine resources. Monitoring is required for compliance with final rules issued under the MMPA, and details of the monitoring program under the Proposed Action have already been developed in coordination with NMFS through the regulatory process for previous Navy at-sea training and testing actions. No changes are anticipated to the monitoring program or reporting that has been conducted to date. However, discussions with resource agencies during the consultation and permitting processes may result in changes to the mitigation as described in this document.

13.1 Monitoring, Research, and Reporting Initiatives

The Navy, NMFS, and the Marine Mammal Commission have held annual adaptive management meetings and additional meetings as needed. These meetings have provided both agencies with an opportunity to clarify information and provide feedback on progress as well as revise monitoring projects and goals within permit cycles.

Dynamic revisions to the monitoring program as a result of adaptive management review include the further development of the Strategic Planning Process (U.S. Department of the Navy, 2013d), which is a planning tool for selection of monitoring investments, and its incorporation into the Integrated Comprehensive Monitoring Program, which was used for subsequent monitoring. Recent monitoring efforts address the Integrated Comprehensive Monitoring Program top-level goals through a collection of specific regional and ocean basin studies based on scientific objectives. The adaptive management review process and reporting requirements serve as the basis for evaluating performance and compliance.

The adaptive management review process is anticipated to continue between the Navy, NMFS, the Marine Mammal Commission, and other experts in the scientific community through technical review meetings and ongoing discussions.

13.2 INTEGRATED COMPREHENSIVE MONITORING PROGRAM

The Integrated Comprehensive Monitoring Program (U.S. Department of the Navy, 2010) provides the overarching framework for coordination of the Navy's marine species monitoring efforts and serves as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the Integrated Comprehensive Monitoring Program is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the Integrated Comprehensive Monitoring Program does not identify specific field work or individual projects, it is designed to provide a flexible, scalable, and adaptable framework using adaptive management and strategic planning processes that periodically assess progress and reevaluate objectives.

The Integrated Comprehensive Monitoring Program is evaluated through the Adaptive Management Review process to (1) assess progress, (2) provide a matrix of goals and objectives, and (3) make recommendations for refinement and analysis of monitoring and mitigation techniques. This process includes conducting an annual adaptive management review meeting at which the Navy and NMFS jointly consider the prior-year goals, monitoring results, and related scientific advances to determine if monitoring plan modifications are warranted to more effectively address program goals. Modifications to the Integrated Comprehensive Monitoring Program that result from annual Adaptive Management Review discussions are incorporated by an addendum or revision to the Integrated Comprehensive Monitoring Program as needed.

Under the Integrated Comprehensive Monitoring Program, Navy-funded monitoring relating to the effects of Navy training and testing activities on protected marine species is designed to accomplish one or more top-level goals as described in the Integrated Comprehensive Monitoring Program charter (U.S. Department of the Navy, 2010):

- An increase in the understanding of the likely occurrence of marine mammals and ESA-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, and density of species)
- An increase in the understanding of the nature, scope, or context of the likely exposure of marine mammals and ESA-listed species to any of the potential stressors associated with the action (e.g., sound, explosive detonation, or expended materials), through better understanding of one or more of the following: (1) the nature of the action and its surrounding environment (e.g., sound-source characterization, propagation, and ambient noise levels), (2) the affected species (e.g., life history or dive patterns), (3) the likely co-occurrence of marine mammals and ESA-listed marine species with the action (in whole or part), and (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and ESA-listed marine species (e.g., age class of exposed animals or known pupping, calving, or feeding areas)
- An increase in the understanding of how individual marine mammals or ESA-listed marine species respond (behaviorally or physiologically) to the specific stressors associated with the action (in specific contexts, where possible [e.g., at what distance or received level])
- An increase in the understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either (1) the long-term fitness and

survival of an individual; or (2) the population, species, or stock (e.g., through impacts on annual rates of recruitment or survival)

- An increase in the understanding of the effectiveness of mitigation and monitoring measures
- A better understanding and record of the manner in which the authorized entity complies with the Incidental Take Authorization and Incidental Take Statement
- An increase in the probability of detecting marine mammals (through improved technology or methods), both specifically within the mitigation zone (thus allowing for more effective implementation of the mitigation) and in general, to better achieve the above goals
- A reduction in the adverse impact of activities to the least practicable level, as defined in the MMPA

In 2011, a Scientific Advisory Group provided specific programmatic recommendations that continue to serve as guiding principles for the continued evolution of the Integrated Comprehensive Monitoring Program. Key recommendations include

- working within a conceptual framework of knowledge, from basic information on the occurrence of species within each range complex, to more specific matters of exposure, response, and consequences;
- facilitating collaboration among researchers in each region, with the intent to develop a coherent and synergistic regional monitoring and research effort; and
- approaching the monitoring program holistically and selecting projects that offer the best opportunity to advance understanding of the issues, as opposed to establishing range-specific requirements.

13.3 Strategic Planning Process

The Strategic Planning Process (U.S. Department of the Navy, 2013d) serves to guide the investment of resources to most efficiently address Integrated Comprehensive Monitoring Program objectives and intermediate scientific objectives developed through this process.

The U.S. Navy marine species monitoring program has evolved and improved as a result of the adaptive management review process through changes that include:

- recognizing the limitations of effort-based compliance metrics;
- developing a conceptual framework based on recommendations from the Scientific Advisory Group (U.S. Department of the Navy, 2013d);
- shifting focus to projects based on scientific objectives that facilitate generation of statistically meaningful results upon which natural resources management decisions may be based;
- focusing on priority species or areas of interest as well as best opportunities to address specific monitoring objectives in order to maximize return on investment; and

- increasing transparency of the program and management standards, improving collaboration among participating researchers, and improving accessibility to data and information resulting from monitoring activities.

As a result, the Navy's marine species monitoring program has undergone a transition with the implementation of the Strategic Planning Process under MMPA authorizations. Under this process, Intermediate Scientific Objectives serve as the basis for developing and executing new monitoring projects across Navy training and testing areas in the Atlantic and Pacific Oceans. Implementation of the Strategic Planning Process involves coordination among fleets, system commands, Chief of Naval Operations Energy and Environmental Readiness Division, NMFS, and the Marine Mammal Commission with five primary steps:

- **Identify overarching intermediate scientific objectives.** Through the adaptive management process, the Navy coordinates with NMFS as well as the Marine Mammal Commission to review and revise the list of intermediate scientific objectives that are used to guide development of individual monitoring projects. Examples include addressing information gaps in species occurrence and density, evaluating behavioral response of marine mammals to Navy training and testing activities, and developing tools and techniques for passive acoustic monitoring.
- **Develop individual monitoring project concepts.** This step generally takes the form of soliciting input from the scientific community in terms of potential monitoring projects that address one or more of the intermediate scientific objectives. This can be accomplished through a variety of forums, including professional societies, regional scientific advisory groups, and contractor support.
- **Evaluate, prioritize, and select monitoring projects.** Navy technical experts and program managers review and evaluate all monitoring project concepts and develop a prioritized ranking. The goal of this step is to establish a suite of monitoring projects that address a cross-section of intermediate scientific objectives spread over a variety of range complexes.
- **Execute and manage selected monitoring projects.** Individual projects are initiated through appropriate funding mechanisms and include clearly defined objectives and deliverables (e.g., data, reports, publications).
- **Report and evaluate progress and results.** Progress on individual monitoring projects is updated through the Navy Marine Species Monitoring Program website as well as annual monitoring reports submitted to NMFS. Both internal review and discussions with NMFS through the adaptive management process are used to evaluate progress toward addressing the primary objectives of the Integrated Comprehensive Monitoring Program and serve to periodically recalibrate the focus of the monitoring program.

These steps serve three primary purposes: (1) to facilitate the Navy in developing specific projects addressing one or more intermediate scientific objectives; (2) to establish a more structured and collaborative framework for developing, evaluating, and selecting monitoring projects across all areas where the Navy conducts training and testing activities; and (3) to maximize the opportunity for input and involvement across the research community, academia, and industry. Furthermore, this process is designed to integrate various elements, including;

- Integrated Comprehensive Monitoring Program top-level goals,

- Scientific Advisory Group recommendations,
- integration of regional scientific expert input,
- ongoing adaptive management review dialog between NMFS and the Navy,
- lessons learned from past and future monitoring at Navy training and testing ranges, and
- leverage of research and lessons learned from other Navy-funded science programs.

The Strategic Planning Process will continue to shape the future of the U.S. Navy Marine Species Monitoring Program and serve as the primary decision-making tool for guiding investments. Information on monitoring projects currently underway in the Atlantic and Pacific oceans, as well as results, reports, and publications can be accessed through the U.S. Navy Marine Species Monitoring Program website (https://www.navymarinespeciesmonitoring.us).

13.4 MONITORING PROGRESS IN NWTT

The monitoring program has undergone significant changes that highlight its progress through adaptive management. The monitoring program developed for the first cycle of environmental compliance documents (e.g., (U.S. Department of the Navy, 2008a, 2008b)) utilized effort-based compliance metrics that were somewhat limiting. Through adaptive management discussions, the Navy designed and conducted monitoring studies according to scientific objectives and eliminated specific effort requirements.

Progress has also been made on the conceptual framework categories from the Scientific Advisory Group for Navy Marine Species Monitoring (U.S. Department of the Navy, 2011a), ranging from occurrence of animals, to their exposure, response, and population consequences. The Navy continues to manage the Atlantic and Pacific program as a whole, with monitoring in each range complex taking a slightly different but complementary approach. The Navy has continued to use the approach of layering multiple simultaneous components in many of the range complexes to leverage an increase in return of the progress toward answering scientific monitoring questions. This included, in the NWTT Study Area for example, (a) satellite tagging of blue whales, fin whales, humpback whales, and Southern Resident killer whales; (b) analysis of existing passive acoustic monitoring datasets; and (c) line-transect aerial surveys for marine mammals in Puget Sound, Washington.

Numerous publications, dissertations and conference presentations have resulted from research conducted under the marine species monitoring program (https://www.navymarinespeciesmonitoring.us/reading-room/publications/), leading to a significant contribution to the body of marine mammal science. Publications on occurrence, distribution, and density have fed the modeling input, and publications on exposure and response have informed Navy and NMFS analysis of behavioral response and consideration of mitigation measures.

Furthermore, collaboration between the monitoring program and the Navy's research and development (e.g., the Office of Naval Research) and demonstration-validation (e.g., Living Marine Resources) programs has been strengthened, leading to research tools and products that have already transitioned to the monitoring program. These include Marine Mammal Monitoring on Ranges, controlled exposure experiment behavioral response studies, acoustic sea glider surveys, and global positioning system-enabled satellite tags. Recent progress has been made with better integration with monitoring across all Navy at-sea study areas, including the Atlantic Fleet Training and Testing Study Area in the Atlantic

Ocean, and various other ranges. Publications from the Living Marine Resources and Office of Naval Research programs have also resulted in significant contributions to hearing, acoustic criteria used in effects modeling, exposure, and response, as well as in developing tools to assess biological significance (e.g., consequences).

NMFS and Navy also consider data collected during procedural mitigation measures as monitoring throughout areas where the Navy trains and tests. Data are collected by shipboard personnel on topic such as hours spent training, hours of observation, hours of sonar, marine mammals observed within the mitigation zone during Major Training Exercises (which are not conducted within the NWTT Study Area), and mitigation measures implemented. This data is provided to NMFS in both classified and unclassified annual exercise reports.

13.5 Proposed Navy-Funded Monitoring

This emphasis on monitoring in the Pacific Northwest is directed at collecting and analyzing tagging data related to the occurrence of blue whales, fin whales, humpback whales, and Southern Resident killer whales. In 2017, researchers deployed 28 tags on blue whales and one tag on a fin whale off southern and central California (Mate et al., 2017). Detailed analyses for the 2017 tagging effort are ongoing and will be available later in a final report. Humpback whales have been tagged with satellite tags, and biopsy samples have been collected (Mate et al., 2017). Location information on Southern Resident killer whales was provided via satellite tag data and acoustic detections (Hanson et al., 2018). Also, distribution of Chinook salmon (a key prey species of Southern Resident killer whales) in coastal waters from Alaska to Northern California was studied (Shelton et al., in review).

Future monitoring efforts will continue along the same objectives: determining the species and populations of marine mammals present and potentially exposed to Navy training and testing activities in the NWTT Study Area, through tagging, passive acoustic monitoring, refined modeling, photo identification, biopsies, and visual monitoring.

13.6 Reporting

Under the current LOA and Biological Opinion, the Navy adheres to the following reporting and coordination requirements:

- Annual total usage of each type of sound source
- Sonar Exercise notification
- Geographic information (the geographic extent of Navy sound source use within NWTT)
- Annual marine species Monitoring Reports (currently combined into two overall reports, one for Pacific and one for Atlantic)
- Annual marine species monitoring technical review meetings with researchers, regulators, and Marine Mammal Commission (currently, every two years a joint meeting is held)
- Annual Adaptive Management meetings with NMFS, regulators, and Marine Mammal Commission (recently modified to occur in conjunction with the annual monitoring meeting)
- Ship strike notification
- Stranding notification

The Navy will discuss the need to continue all of these requirements with NMFS during the MMPA and ESA consultations.

14 Suggested Means of Coordination

14.1 Overview

The U.S. Navy is one of the world's leading organizations in assessing the effects of human activities on the marine environment, including marine mammals. Navy scientists work cooperatively with other government researchers and scientists, universities, industry, and non-governmental conservation organizations in collecting, evaluating, and modeling information on marine resources. They also develop approaches to ensure that these resources are minimally impacted by existing and future Navy operations. There are three pillars to the Navy's monitoring and research program: the Research and Development programs under the Navy's Chief of Naval Operations Energy and Environmental Readiness (OPNAV N45), the Office of Naval Research marine mammal and biology program, and the Fleet/Systems Commands compliance monitoring program. The goal of the Navy's Research and Development program is to enable collection and publication of scientifically valid research as well as development of techniques and tools for Navy, academic, and commercial use. Research and Development programs are funded and developed by OPNAV N45 and the Office of Naval Research, Code 322 Marine Mammals and Biological Oceanography Program. Since the 1990s, the primary focus of these programs has been understanding the effects of sound on marine mammals, including physiological, behavioral, and ecological effects. The third pillar of the Navy's marine species research and monitoring programs is the Fleet Systems Command compliance program that started in 2009 with the first MMPA permits. Coordination is frequent between the three programs, with members of each program sitting on advisory or steering committees of the others' to facilitate collaboration, transition, and feedback loops to all three.

The Office of Naval Research's current Marine Mammals and Biology Program thrusts include, but are not limited to (1) monitoring and detection research; (2) integrated ecosystem research, including sensor and tag development; (3) effects of sound on marine life (such as hearing, behavioral response studies, physiology [diving and stress], Population Consequences of Acoustic Disturbance); and (4) models and databases for environmental compliance.

To manage some of the Navy's marine mammal research programmatic elements, in 2011 OPNAV N45 developed a new Living Marine Resources Research and Development Program. The goal of the Living Marine Resources Research and Development Program is to identify and fill knowledge gaps and to demonstrate, validate, and integrate new processes and technologies to minimize potential effects to marine mammals and other marine resources. The Living Marine Resources has an Advisory Committee comprised of Navy biologists and staff from the Fleets, Systems Commands, and service providers, providing a nexus for feedback and collaboration for the three pillars of the Navy's Research and Monitoring programs. Key elements of the Living Marine Resources program include

- develop an open and transparent process with a dedicated web site for both project management and public review;
- provide program management and execution, including inputs from various Navy commands involved in monitoring and research;
- ensure funding of research and development projects that include internationally respected and authoritative researchers and institutions;
- establish and validate critical needs and requirements with input from a Navy Regional Advisory Committee;

- interact with key stakeholders outside of the Navy via the Regional Advisory Committee;
- identify key enabling capabilities and investment areas with advice and assistance from a Navy Technical Review Committee;
- maintain close interaction and coordination with the Office of Naval Research's basic and early-stage applied research program;
- develop effective information for Navy environmental planners and operators; and
- provide effective management of project funding.

The Navy also collaborates regularly with the Bureau of Ocean Energy Management, NMFS, and other federal agencies on projects with mutual goals. Examples are Atlantic Marine Assessment Program for Protected Species; Pacific Marine Assessment Program for Protected Species; and monitoring projects in the Mariana Islands, Hawaii, Southern California, and the Atlantic.

14.2 Navy Research and Development

14.2.1 Navy Funded Research

In the Study Area, because training and testing events are, by comparison to other Navy areas, less frequent and generally small in scope, the majority of Navy's research effort has been focused elsewhere. Despite this, funding by the Navy has provided much of the marine mammal science collected in the Pacific Northwest. Since the 2015 NWTT Final EIS/OEIS and the issuance of the current authorization, new research has continued to be funded by the Navy in the Pacific Northwest and has included, but not been limited to the following:

- The continuation of Southern Resident killer whale passive acoustic monitoring, model development, and analysis of multi-year archival data.
- Humpback whale tagging in support of marine mammal monitoring across multiple Navy training and testing areas in the Pacific Ocean, including the NWTT Study Area.
- Characterizing the distribution of salmonids in the Pacific Northwest with pop-up satellite tags.

As detailed in the 2015 NWTT Final EIS/OEIS, these reporting, monitoring, and research efforts by the Navy have added to the baseline data for marine mammal species inhabiting the Study Area. In addition, subsequent research and monitoring across the Navy has continued to broaden the sample of observations regarding the general health of marine mammal populations in locations where the Navy has been conducting training and testing activities for decades, which has been considered in the analysis of marine mammal impacts presented in this Request for LOAs in the same manner that the previous findings were used in the analyses associated with the 2015 NWTT Final EIS/OEIS, the prior NMFS authorization of takes under MMPA in the Study Area, and the NMFS Biological Opinion pursuant to the ESA (National Marine Fisheries Service, 2015).

14.2.2 Other Government Funded Research

The Navy also periodically coordinates with, shares information with, and on occasion contributes funding to NMFS' Southwest Fisheries Science Center, which conducts marine mammal studies along the U.S. West Coast. The objective of this coordination is to ensure both agencies are aware of each other's efforts, as well as aware of data and resource gaps when specific projects overlap with the Navy's interests in the Pacific Northwest.

15 List of Preparers

Andrea Balla-Holden (Commander, U.S. Pacific Fleet)
B.S., Fisheries
Years of experience: 26

Victoria Bowman (National Marine Mammal Foundation), Environmental Scientist
B.A., Psychology
Years of experience: 6

Conrad Erkelens (ManTech International), Senior Scientist
M.A., Anthropology
B.A., Anthropology
Years of experience: 20

Peter Hulton (Naval Undersea Warfare Center, Division Newport), Technical Project Manager
B.S., Mechanical Engineering
Years of experience: 33

Keith Jenkins (Space & Naval Warfare Systems Command), Marine Scientist
M.S., Fisheries Oceanography
B.S., Marine Biology
Years of experience: 16

Rose Johnson (Naval Sea Systems Command, Environmental Protection Specialist, Environmental Planning Branch)
M.S., Environmental Management
B.S., Environmental Science and Policy
Years of experience: 9

Sarah Kotecki (Space & Naval Warfare Systems Command Pacific), Engineer
B.S., Civil and Environmental Engineering
Years of experience: 16

Kimberly Kler (Naval Facilities Engineering Command, Northwest), Project Manager
B.S., Environmental Policy, Analysis and Planning
Years of experience: 24

John Mosher (Commander, U.S. Pacific Fleet)
B.S., Geology
Years of experience: 31

Nicholas Paraskevas (Naval Air Systems Command)
B.S., Aerospace and Ocean Engineering
Years of experience: 43

Jennifer Paulk (Naval Air Systems Command)
M.S., Physiology
B.S., Psychology
Years of experience: 22

Corey Pressley Plakos (Naval Air Systems Command Patuxent River)
M.S., Conservation and Marine Ecology
Years of experience: 15

Sarah Rider (G2 Software Systems), Natural Resources Management Specialist
M.E.M., Coastal Environmental Management
B.S., Marine Science
Years of experience: 10

Stephanie Sleeman (Naval Facilities Engineering Command Northwest)
M.E.S., Environmental Science
B.A., Environmental Policy and Planning; Minor, Marine Science
Years of experience: 14

Brian D. Wauer (ManTech International), Project Manager
B.S., Administrative Management
B.S., Industrial Management
Years of experience: 31

Mike Zickel (ManTech International)
M.S., Marine Estuarine Environmental Sciences
B.S., Physics
Years of experience: 21

16 BIBLIOGRAPHY

Abrahms, B., E. L. Hazen, S. J. Bograd, J. S. Brashares, P. W. Robinson, K. L. Scales, D. E. Crocker, and D. P. Costa. (2017). Climate mediates the success of migration strategies in a marine predator. *Ecology Letters, 21*(1), 63–71.

Adams, J., J. Felis, J. W. Mason, and J. Y. Takekawa. (2014). *Pacific Continental Shelf Environmental Assessment (PaCSEA): Aerial Seabird and Marine Mammal Surveys off Northern California, Oregon, and Washington, 2011–2012* (OCS Study BOEM 2014-003). Camarillo, CA: Bureau of Ocean Energy Management.

Aguilar de Soto, N., M. Johnson, P. T. Madsen, P. L. Tyack, A. Bocconcelli, and J. F. Borsani. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science, 22*(3), 690–789.

Akamatsu, T., K. Nakamura, H. Nitto, and M. Watabe. (1996). Effects of underwater sounds on escape behavior of Steller sea lions. *Fisheries Science, 62*(4), 503–510.

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.

Alter, S. E., S. F. Ramirez, S. Nigenda, J. U. Ramirez, L. R. Bracho, and S. R. Palumbi. (2009). Mitochondrial and nuclear genetic variation across calving lagoons in Eastern North Pacific gray whales (*Eschrichtius robustus*). *The Journal of Heredity, 100*(1), 34–46.

Alves, A., R. Antunes, A. Bird, P. L. Tyack, P. J. O. Miller, F. P. A. Lam, and P. H. Kvadsheim. (2014). Vocal matching of naval sonar signals by long-finned pilot whales (*Globicephala melas*). *Marine Mammal Science, 30*(3), 1248–1257.

Antunes, R., P. H. Kvadsheim, F. P. Lam, P. L. Tyack, L. Thomas, P. J. Wensveen, and P. J. Miller. (2014). High thresholds for avoidance of sonar by free-ranging long-finned pilot whales (*Globicephala melas*). *Marine Pollution Bulletin, 83*(1), 165–180.

Aquatic Mammals. (2015). Supplemental tables: Biologically important areas for selected cetaceans within U.S. Waters – West Coast region. *Aquatic Mammals, 41*(1), 30–32.

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.

Astrup, J., and B. Mohl. (1993). Detection of Intense Ultrasound by the Cod *Gadus Morhua*. *The Journal of Experimental Biology, 182*, 71–80.

Astrup, J. (1999). Ultrasound detection in fish—A parallel to the sonar-mediated detection of bats by ultrasound-sensitive insects? *Comparative Biochemistry and Physiology, Part A, 124*, 19–27.

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, 185*, 463–486.

Au, W. W. L., R. W. Floyd, R. H. Penner, and A. E. Murchison. (1974). Measurement of echolocation signals of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu, in open waters. *The Journal of the Acoustical Society of America, 56*(4), 1280–1290.

Au, W. W. L., and P. W. B. Moore. (1990). Critical ratio and critical bandwidth for the Atlantic bottlenose dolphin. *The Journal of the Acoustical Society of America, 88*(3), 1635–1638.

Au, W. W. L. (1993). *The Sonar of Dolphins*. New York, NY: Springer-Verlag.

Aurioles-Gamboa, D., and F. J. Camacho-Rios. (2007). Diet and feeding overlap of two otariids, *Zalophus californianus* and *Arctocephalus townsendi*: Implications to survive environmental uncertaintly. *Aquatic Mammals, 33*(3), 315–326.

Aurioles-Gamboa, D., F. Elorriaga-Verplancken, and C. J. Hernandez-Camacho. (2010). The current population status of Guadalupe fur seal (*Arctocephalus townsendi*) on the San Benito Islands, Mexico. *Marine Mammal Science, 26*(2), 402–408.

Avens, L. (2003). Use of multiple orientation cues by juvenile loggerhead sea turtles *Caretta caretta*. *The Journal of Experimental Biology, 206*(23), 4317–4325.

Ayres, K. L., R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, and S. K. Wasser. (2012). Distinguishing the impacts of inadequate prey and vessel traffic on an endangered killer whale (*Orcinus orca*) population. *PLoS ONE, 7*(6), e36842.

Azzellino, A., S. Gaspari, S. Airoldi, and B. Nani. (2008). Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. *Deep Sea Research Part I: Oceanographic Research Papers, 55*(3), 296–323.

Bailey, H., B. R. Mate, D. M. Palacios, L. Irvine, S. J. Bograd, and D. P. Costa. (2009). Behavioral estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. *Endangered Species Research, 10*, 93–106.

Bailey, H., P. S. Hammond, and P. M. Thompson. (2014). Modelling harbour seal habitat by combining data from multiple tracking systems. *Journal of Experimental Marine Biology and Ecology, 450*, 30–39.

Bain, D. E. (2002). *A Model Linking Energetic Effects of Whale Watching to Killer Whale (Orcinus orca) Population Dynamics*. Friday Harbor, WA: Friday Harbor Laboratories, University of Washington.

Baird, R. (2013). Odontocete Cetaceans Around the Main Hawaiian Islands: Habitat Use and Relative Abundance from Small-Boat Sighting Surveys. *Aquatic Mammals, 39*(3), 253–269.

Baird, R. W. (2001). Status of harbour seals*, Phoca vitulina*, in Canada. *The Canadian Field-Naturalist, 115*(4), 663–675.

Baird, R. W., and A. M. Gorgone. (2005). False killer whale dorsal fin disfigurements as a possible indicator of long-line fishery interactions in Hawaiian waters. *Pacific Science, 59*(4), 593–601.

Baird, R. W., G. Schorr, D. L. Webster, D. J. McSweeney, B. Hanson, and R. D. Andrews. (2010). *Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaii: Results from satellite tagging in 2009/2010*. Olympia, WA: Cascadia Research Collective.

Baird, R. W., J. A. Shaffer, D. L. Webster, S. D. Fisher, J. M. Aschettino, A. M. Gorgone, B. K. Rone, S. D. Mahaffy, and D. J. Moretti. (2013). *Odontocete Studies Off the Pacific Missile Range Facility in February 2013: Satellite-Tagging, Photo Identification, and Passive Acoustic Monitoring for Species Verification*. Olympia, WA and Newport, RI: U.S. Navy Pacific Fleet.

Baird, R. W., S. M. Jarvis, D. L. Webster, B. K. Rone, J. A. Shaffer, S. D. Mahaffy, A. M. Gorgone, and D. J. Moretti. (2014). *Odontocete Studies on the Pacific Missile Range Facility in July/August 2013: Satellite-Tagging, Photo Identification, and Passive Acoustic Monitoring*. Olympia, WA and Newport, RI: U.S. Navy Pacific Fleet.

Baird, R. W., D. L. Webster, S. Watwood, R. Morrissey, B. K. Rone, S. D. Mahaffy, A. M. Gorgone, D. B. Anderson, and D. J. Moretti. (2016). *Odontocete Studies on the Pacific Missile Range Facility in February 2015: Satellite-Tagging, Photo-Identification, and Passive Acoustic Monitoring. Final Report*. Olympia, WA: HDR Environmental Inc.

Baird, R. W., S. D. Mahaffy, A. M. Gorgone, K. A. Beach, T. Cullins, D. J. McSweeney, D. S. Verbeck, and D. L. Webster (2017a). *Updated Evidence of Interactions Between False Killer Whales and Fisheries Around the Main Hawaiian Islands: Assessment of Mouthline and Dorsal Fin Injuries*. Olympia, WA: Cascadia Research Collective.

Baird, R. W., S. W. Martin, R. Manzano-Roth, D. L. Webster, and B. L. Southall. (2017b). *Assessing Exposure and Response of Three Species of Odontocetes to Mid-frequency Active Sonar During*

Submarine Commanders Courses at the Pacific Missile Range Facility: August 2013 through February 2015. Draft Report. Honolulu, HI: HDR, Inc.

Baker, C. S., V. Lukoschek, S. Lavery, M. L. Dalebout, M. Yong-un, T. Endo, and N. Funahashi. (2006). Incomplete reporting of whale, dolphin and porpoise 'bycatch' revealed by molecular monitoring of Korean markets. *Animal Conservation, 9*(4), 474–482.

Bakhchina, A. V., L. M. Mukhametov, V. V. Rozhnov, and O. I. Lyamin. (2017). Spectral analysis of heart rate variability in the beluga (*Delphinapterus leucas*) during exposure to acoustic noise. *Journal of Evolutionary Biochemistry and Physiology, 53*(1), 60–65.

Barlow, J. (1988). Harbor Porpoise, *Phocoena phocoena*, Abundances Estimation for California, Oregon, and Washington: I. Ship Surveys. *Fishery Bulletin, 86*(3), 417–432.

Barlow, J. (1994). Abundance of large whales in California coastal waters: A comparison of ship surveys in 1979–1980 and in 1991. *Report of the International Whaling Commission, 44*, 399–406.

Barlow, J. (1997). *Preliminary Estimates of Cetacean Abundance off California, Oregon and Washington based on a 1996 Ship Survey and Comparisons of Passing and Closing Modes*. La Jolla, CA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Barlow, J. (2003). *Preliminary Estimates of the Abundance of Cetaceans Along the U.S. West Coast: 1991–2001*. Silver Spring, MD: National Marine Fisheries Service—Southwest Fisheries Science Center.

Barlow, J., and K. A. Forney. (2007). Abundance and population density of cetaceans in the California Current ecosystem. *Fishery Bulletin, 105*, 509–526.

Barlow, J., M. Ferguson, E. Becker, J. Redfern, K. Forney, I. Vilchis, P. Fiedler, T. Gerrodette, and L. Ballance. (2009). *Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean* (NOAA Technical Memorandum NMFS-SWFSC-444). La Jolla, CA: Southwest Fisheries Science Center.

Barlow, J. (2010). *Cetacean Abundance in the California Current Estimated from a 2008 Ship-Based Line-Transect Survey* (NOAA Technical Memorandum NMFS-SWFSC-456). La Jolla, CA: Southwest Fisheries Science Center.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn, II, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R, P. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. *Marine Mammal Science, 27*(4), 793–818.

Barlow, J. (2016). *Cetacean Abundance in the California Current Estimated from Ship-based Line-transect Surveys in 1991–2014.* (NOAA Administrative Report NMFS-SWFSC-LJ-1601). La Jolla, CA: Southwest Fisheries Science Center.

Barnard, B. (2016). Carriers stick with slow-steaming despite fuel-price plunge. *The Journal of Commerce*. Retrieved from http://www.joc.com/maritime-news/container-lines/carriers-stick-slow-steaming-despite-fuel-price-plunge_20160401.html.

Baumann-Pickering, S., A. E. Simonis, M. A. Roch, M. A. McDonald, A. Solsona-Berga, E. M. Oleson, S. M. Wiggins, R. L. Brownell, Jr., and J. A. Hildebrand. (2012). *Spatio-temporal patterns of beaked whale echolocation signals in the North Pacific* (2012 Marine Mammal & Biology Program Review). Arlington, VA: Office of Naval Research.

Baumann-Pickering, S., M. A. Roch, R. L. Brownell, Jr., A. E. Simonis, M. A. McDonald, A. Solsona-Berga, E. M. Oleson, S. M. Wiggins, and J. A. Hildebrand. (2014). Spatio-temporal patterns of beaked whale echolocation signals in the north Pacific. *PLoS ONE, 9*(1), e86072.

Baumgartner, M. F. (1997). The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. *Marine Mammal Science, 13*(4), 614–638.

Becker, E. A., K. A. Forney, M. C. Ferguson, D. G. Foley, R. C. Smith, J. Barlow, and J. V. Redfern. (2010). Comparing California Current cetacean–habitat models developed using in situ and remotely sensed sea surface temperature data. *Marine Ecology Progress Series, 413*, 163–183.

Becker, E. A., K. A. Forney, M. C. Ferguson, J. Barlow, and J. V. Redfern. (2012a). *Predictive Modeling of Cetacean Densities in the California Current Ecosystem based on Summer/Fall Ship Surveys in 1991–2008* (NOAA Technical Memorandum NMFS-SWFSC-499). La Jolla, CA: Southwest Fisheries Science Center.

Becker, E. A., K. A. Forney, D. G. Foley, and J. Barlow. (2012b). *Density and Spatial Distribution Patterns of Cetaceans in the Central North Pacific based on Habitat Models* (NOAA Technical Memorandum NMFS-SWFSC-490). La Jolla, CA: Southwest Fisheries Science Center.

Becker, E. A., K. A. Forney, D. G. Foley, R. C. Smith, T. J. Moore, and J. Barlow. (2014). Predicting seasonal density patterns of California cetaceans based on habitat models. *Endangered Species Research, 23*(1), 1–22.

Becker, E. A., K. A. Forney, P. C. Fiedler, J. Barlow, S. J. Chivers, C. A. Edwards, A. M. Moore, and J. V. Redfern. (2016). Moving Towards Dynamic Ocean Management: How Well Do Modeled Ocean Products Predict Species Distributions? *Remote Sensing, 8*(2), 149.

Becker, E. A., K. A. Forney, B. J. Thayre, A. J. Debich, G. S. Campbell, K. Whitaker, A. B. Douglas, A. Gilles, R. Hoopes, and J. A. Hildebrand. (2017). Habitat-Based Density Models for Three Cetacean Species off Southern California Illustrate Pronounced Seasonal Differences. *Frontiers in Marine Science, 4*(121), 1–14.

Bejder, L., A. Samuels, H. Whitehead, and N. Gales. (2006a). Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour, 72*, 1149–1158.

Bejder, L., A. Samuels, H. Whitehead, N. Gales, J. Mann, R. Connor, M. Heithaus, J. Waston-Capps, C. Flaherty, and M. Krützen. (2006b). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology, 20*(6), 1791–1798.

Bergström, L., L. Kautsky, T. Malm, R. Rosenberg, M. Wahlberg, N. Åstrand Capetillo, and D. Wilhelmsson. (2014). Effects of offshore wind farms on marine wildlife–A generalized impact assessment. *Environmental Research Letters, 9*(3), 12.

Berini, C. R., L. M. Kracker, and W. E. McFee. (2015). *Modeling Pygmy Sperm Whale (Kogia breviceps) Strandings Along the Southeast Coast of the United States from 1992 to 2006 in Relation to Environmental Factors* (NOAA Technical Memorandum NOS-NCCOS-203). Charleston, SC: National Oceanic and Atmospheric Administration.

Bernaldo de Quiros, Y., O. Gonzalez-Diaz, M. Arbelo, E. Sierra, S. Sacchini, and A. Fernandex. (2012). Decompression vs. decomposition: Distribution, amount, and gas composition of bubbles in stranded marine mammals. *Frontiers in Physiology, 3 Article 177*, 19.

Bernaldo de Quiros, Y., O. Gonzalez-Diaz, A. Mollerlokken, A. O. Brubakk, A. Hjelde, P. Saavedra, and A. Fernandez. (2013a). Differentiation at autopsy between in vivo gas embolism and putrefaction using gas composition analysis. *International Journal of Legal Medicine, 127*(2), 437–445.

Bernaldo de Quiros, Y., J. S. Seewald, S. P. Sylva, B. Greer, M. Niemeyer, A. L. Bogomolni, and M. J. Moore. (2013b). Compositional discrimination of decompression and decomposition gas bubbles in bycaught seals and dolphins. *PLoS ONE, 8*(12), e83994.

Bernaldo de Quirós, Y., A. Fernandez, R. W. Baird, R. L. Brownell, N. Aguilar de Soto, D. Allen, M. Arbelo, M. Arregui, A. Costidis, A. Fahlman, A. Frantzis, F. M. D. Gulland, M. Iñíguez, M. Johnson, A. Komnenou, H. Koopman, D. A. Pabst, W. D. Roe, E. Sierra, M. Tejedor, and G. Schorr. (2019). Advances in research on the impacts of anti-submarine sonar on beaked whales. *Proceedings of the Royal Society B: Biological Sciences, 286*(1895), 20182533.

Bernard, H. J., and S. B. Reilly. (1999). Pilot whales, *Globicephala* Lesson, 1828. In S. H. Ridgway & R. Harrison (Eds.), *Handbook of Marine Mammals* (Vol. 6, pp. 245–280). San Diego, CA: Academic Press.

Best, B. D., C. H. Fox, R. Williams, P. N. Halpin, and P. C. Paquet. (2015). Updated marine mammal distribution and abundance estimates in British Columbia. *Journal of Cetacean and Research Management, 15*, 9–26.

Best, P. B., and C. H. Lockyer. (2002). Reproduction, growth and migrations of sei whales, *Balaenoptera borealis,* off the west coast of South Africa. *South African Journal of Marine Science, 24*(1), 111–133.

Bester, M. N., J. W. H. Ferguson, and F. C. Jonker. (2002). Population densities of pack ice seals in the Lazarev Sea, Antarctica. *Antarctic Science, 14*(2), 123–127.

Bettridge, S., C. S. Baker, J. Barlow, P. J. Clapham, M. Ford, D. Gouveia, D. K. Mattila, R. M. Pace, III, P. E. Rosel, G. K. Silber, and P. R. Wade. (2015). *Status Review of the Humpback Whale (Megaptera novaeangliae) under the Endangered Species Act* (NOAA Technical Memorandum NMFS-SWFSC-540). La Jolla, CA: Southwest Fisheries Science Center.

Bickel, S. L., J. D. Malloy Hammond, and K. W. Tang. (2011). Boat-generated turbulence as a potential source of mortality among copepods. *Journal of Experimental Marine Biology and Ecology, 401*(1–2), 105–109.

Bishop, M. J. (2008). Displacement of epifauna from seagrass blades by boat wake. *Journal of Experimental Marine Biology and Ecology, 354*(1), 111–118.

Black, N. A. (2011). *Fish-eating (Resident) Killer Whales Sighted in Monterey Bay on Feb. 10, 2011*. Retrieved from http://www.montereybaywhalewatch.com/Features/PugetSoundKillerWhales1102.htm.

Blackwell, S. B., J. W. Lawson, and M. T. Williams. (2004). Tolerance by ringed seals (*Phoca hispida*) to impact pipe-driving and construction sounds at an oil production island. *The Journal of the Acoustical Society of America, 115*(5 [Pt. 1]), 2346–2357.

Blackwell, S. B., C. S. Nations, T. L. McDonald, C. R. Greene, A. M. Thode, M. Guerra, and A. M. Macrander. (2013). Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. *Marine Mammal Science, 29*, E342–E365.

Blackwell, S. B., C. S. Nations, T. L. McDonald, A. M. Thode, D. Mathias, K. H. Kim, C. R. Greene, Jr., and A. M. Macrander. (2015). Effects of airgun sounds on bowhead whale calling rates: Evidence for two behavioral thresholds. *PLoS ONE, 10*(6), e0125720.

Blackwell, S. B., C. S. Nations, A. M. Thode, M. E. Kauffman, A. S. Conrad, R. G. Norman, and K. H. Kim. (2017). Effects of tones associated with drilling activities on bowhead whale calling rates. *PLoS ONE, 12*(11), e0188459.

Bonnell, M. L., and M. D. Dailey. (1993). Marine Mammals. In M. D. Dailey, D. J. Reish, & J. W. Anderson (Eds.), *Ecology of the Southern California Bight: A Synthesis and Interpretation* (pp. 604–682). Los Angeles, CA: University of California Press.

Bonney, J., and P. T. Leach. (2010). Slow Boat From China. *Maritime News*. Retrieved from http://www.joc.com/maritimenews/slowboatchina_20100201.html.

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. *The Journal of the Acoustical Society of America, 96*, 2469–2484.

Boyd, I., D. Claridge, C. Clark, and B. Southall. (2008). *BRS 2008 Preliminary Report*. Washington, DC: U.S. Navy NAVSEA PEO IWS 5, ONR, U.S. Navy Environmental Readiness Division, National Oceanic and Atmospheric Administration, Strategic Environmental Research and Development Program.

Bradford, A. L., and E. Lyman. (2015). *Injury Determinations for Humpback Whales and Other Cetaceans Reported to NOAA Response Networks in the Hawaiian Islands During 2007–2012* (NOAA Technical Memorandum NMFS-PIFSC-45). Honolulu, HI: Pacific Islands Fisheries Science Center.

Bradshaw, C. J. A., K. Evans, and M. A. Hindell. (2006). Mass cetacean strandings—A plea for empiricism. *Conservation Biology, 20*(2), 584–586.

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.

Branch, T. A., K. M. Stafford, D. M. Palacios, C. Allison, J. L. Bannister, C. L. K. Burton, E. Cabrera, C. A. Carlson, B. Galletti Vernazzani, P. C. Gill, R. Hucke-Gaete, K. C. S. Jenner, M. N. M. Jenner, K. Matsuoka, Y. A. Mikhalev, T. Miyashita, M. G. Morrice, S. Nishiwaki, V. J. Sturrock, D. Tormosov, R. C. Anderson, A. N. Baker, P. B. Best, P. Borsa, R. L. Brownell Jr, S. Childerhouse, K. P. Findlay, T. Gerrodette, A. D. Ilangakoon, M. Joergensen, B. Kahn, D. K. Ljungblad, B. Maughan, R. D. McCauley, S. McKay, T. F. Norris, S. Rankin, F. Samaran, D. Thiele, K. Van Waerebeek, and R. M. Warneke. (2007). Past and present distribution, densities and movements of blue whales Balaenoptera musculus in the Southern Hemisphere and northern Indian Ocean. *Mammal Review, 37*(2), 116–175.

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*). *The Journal of the Acoustical Society of America, 1*, 625–633.

Branstetter, B. K., J. S. Trickey, K. Bakhtiari, A. Black, H. Aihara, and J. J. Finneran. (2013). Auditory masking patterns in bottlenose dolphins (*Tursiops truncatus*) with natural, anthropogenic, and synthesized noise. *The Journal of the Acoustical Society of America, 133*(3), 1811–1818.

Branstetter, B. K., K. Bakhtiari, A. Black, J. S. Trickey, J. J. Finneran, and H. Aihara. (2016). Energetic and informational masking of complex sounds by a bottlenose dolphin (*Tursiops truncatus*). *The Journal of the Acoustical Society of America, 140*(3), 1904–1917.

Branstetter, B. K., J. St. Leger, D. Acton, J. Stewart, D. Houser, J. J. Finneran, and K. Jenkins. (2017a). Killer whale (*Orcinus orca*) behavioral audiograms. *The Journal of the Acoustical Society of America, 141*, 2387–2398.

Branstetter, B. K., K. R. Van Alstyne, T. A. Wu, R. A. Simmons, L. D. Curtis, and M. J. Xitco, Jr. (2017b). Critical ratio functions for odontocete cetaceans. *The Journal of the Acoustical Society of America, 142*(4), 1897–1900.

Braun, C. B., and T. Grande. (2008). Evolution of Peripheral Mechanisms for the Enhancement of Sound Reception. In. In J. F. Webb, A. N. Popper, & R. R. Fay (Eds.), *Fish Bioacoustics* (pp. 99–144). New York, NY: Springer-Verlag.

Briggs, C., S. M. Shjegstad, J. A. K. Silva, and M. H. Edwards. (2016). Distribution of chemical warfare agent, energetics, and metals in sediments at a deep-water discarded military munitions site. *Deep Sea Research Part II: Topical Studies in Oceanography, 128*, 63–69.

Brown, R. F., and B. R. Mate. (1983). Abundance, movements, and feeding habits of harbor seals, *Phoca vitulina*, at Netarts and Tillamook Bays, Oregon. *Fishery Bulletin, 81*(2), 291–301.

Brownell, R. L., Jr., W. A. Walker, and K. A. Forney. (1999). Pacific white-sided dolphin, *Lagenorhynchus obliquidens* Gill, 1865. In S. H. Ridgway & R. Harrison (Eds.), *Handbook of Marine Mammals* (Vol. 6, pp. 57–84). Cambridge, MA: Academic Press.

Brownell, R. L., Jr., P. J. Clapham, T. Miyashita, and T. Kasuya. (2001). Conservation status of North Pacific right whales. *Journal of Cetacean Research and Management, Special Issue 2*, 269–286.

Bruintjes, R., J. Purser, K. A. Everley, S. Mangan, S. D. Simpson, and A. N. Radford. (2016). Rapid recovery following short–term acoustic disturbance in two fish species. *Royal Society - Open Science, 3*(1), 150686.

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. In M. L. Jones, S. L. Swartz, & S. Leatherwood (Eds.), *The Gray Whale: Eschrichtius robustus* (pp. 375–387). Orlando, FL: Academic Press.

Burnham, R., D. Duffus, and X. Mouy. (2018). Gray Whale (*Eschrictius robustus*) Call Types Recorded During Migration off the West Coast of Vancouver Island. *Frontiers in Marine Science, 5*(329), 1–11.

Calambokidis, J., and R. W. Baird. (1994). *Status of Marine Mammals in the Strait of Georgia, Puget Sound and the Juan de Fuca Strait and Potential Human Impacts* (Symposium on the Marine Environment). Olympia, WA: Cascadia Research Collective.

Calambokidis, J., J. D. Darling, V. Deecke, P. Gearin, M. Gosho, W. Megill, C. M. Tombach, D. Goley, C. Toropova, and B. Gisborne. (2002). Abundance, range and movements of a feeding aggregation of gray whales (*Eschrichtius robustus*) from California to southeastern Alaska in 1998. *Journal of Cetacean Research and Management, 4*(3), 267–276.

Calambokidis, J., and J. Barlow. (2004). Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. *Marine Mammal Science, 20*(1), 63–85.

Calambokidis, J., G. H. Steiger, D. K. Ellifrit, B. L. Troutman, and C. E. Bowlby. (2004). Distribution and abundance of humpback whales (*Megaptera novaeangliae*) and other marine mammals off the northern Washington coast. *Fishery Bulletin, 102*, 563–580.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. (2008). *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific*. Olympia, WA: Cascadia Research.

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. Huggins. (2009b). *Photographic Identification of Humpback and Blue Whales off the U.S. West Coast: Results and Updated Abundance Estimates from 2008 Field Season*. La Jolla, CA: Southwest Fisheries Science Center, and Olympia, WA: Cascadia Research Collective.

Calambokidis, J., J. L. Laake, and A. Klimek. (2010). *Abundance and Population Structure of Seasonal Gray Whales in the Pacific Northwest, 1998–2008*. Washington, DC: International Whaling Commission Scientific Committee.

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* (PSRG-2013-13R). Olympia, WA and La Jolla, CA: Cascadia Research and Southwest Fisheries Science Center.

Calambokidis, J., G. H. Steiger, C. Curtice, J. Harrison, M. C. Ferguson, E. Becker, M. DeAngelis, and S. M. Van Parijs. (2015). Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region. *Aquatic Mammals (Special Issue), 41*(1), 39–53.

Calambokidis, J., J. Barlow, K. Flynn, E. Dobson, and G. H. Steiger. (2017a). *Update on abundance, trends, and migrations of humpback whales along the U.S. West Coast* (SC/A17/NP/13). Cambridge, United Kingdom: International Whaling Commission.

Calambokidis, J., J. Laake, and A. Perez. (2017b). *Updated analysis of abundance and population structure of seasonal gray whales in the Pacific Northwest, 1996–2015*. Cambridge, United Kingdom: International Whaling Commission.

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 the National Marine Fisheries Service September 15, 2010*. San Diego, CA: U.S. Department of the Navy.

Campbell, G. S., L. Thomas, K. Whitaker, A. B. Douglas, J. Calambokidis, and J. A. Hildebrand. (2015). Inter-annual and seasonal trends in cetacean distribution, density and abundance off southern California. *Deep Sea Research Part II: Topical Studies in Oceanography, 112*, 143–157.

Cañadas, A., R. Sagarminaga, and S. García-Tiscar. (2002). Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep-Sea Research I, 49*, 2053–2073.

Carr, R. S., and M. Nipper. (2003). *Assessment of Environmental Effects of Ordnance Compounds and their Transformation Products in Coastal Ecosystems*. Port Hueneme, CA: Naval Facilities Engineering Service Center.

Carretta, J. V., M. S. Lynn, and C. A. LeDuc. (1994). Right whale (*Eubalaena Glacialis*) sighting off San Clemente Island, California. *Marine Mammal Science, 10*(1), 101–105.

Carretta, J. V., J. Barlow, and L. Enriquez. (2008). Acoustic pingers eliminate beaked whale bycatch in a gill net fishery. *Marine Mammal Science, 24*(4), 2053–2073.

Carretta, J. V., E. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, B. Hanson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, D. Lynch, L. Carswell, R. L. J. Brownell, D. K. Mattila, and M. C. Hill. (2013a). *U.S. Pacific Marine Mammal Stock Assessments: 2012* (NOAA Technical Memorandum NMFS-SWFSC-504). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., S. M. Wilkin, M. M. Muto, and K. Wilkinson. (2013b). *Sources of Human-Related Injury and Mortality for U.S. Pacific West Coast Marine Mammal Stock Assessments, 2007–2011* (NOAA Technical Memorandum NMFS-SWFSC-514). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., E. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. Moore, D. Lynch, L. Carswell, and R. L. Brownell. (2015). *U.S. Pacific Marine Mammal Stock Assessments: 2014* (NOAA Technical Memorandum NMFS-SWFSC-549). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., K. Danil, S. J. Chivers, D. W. Weller, D. S. Janiger, M. Berman-Kowalewski, K. M. Hernandez, J. T. Harvey, R. C. Dunkin, D. R. Casper, S. Stoudt, M. Flannery, K. Wilkinson, J. Huggins, and D. M. Lambourn. (2016a). 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., M. M. Muto, S. Wilkin, J. Greenman, K. Wilkinson, M. DeAngelis, J. Viezbicke, D. Lawson, and J. Jannot. (2016b). *Sources of Human-Related Injury and Mortality for U.S. Pacific West Coast Marine Mammal Stock Assessments, 2010–2014*. La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., E. M. Oleson, J. Baker, D. W. Weller, A. R. Lang, K. A. Forney, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell Jr. (2016c). *U.S. Pacific Marine Mammal Stock Assessments: 2015*. La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., J. E. Moore, and K. A. Forney. (2017a). *Regression Tree and Ratio Estimates of Marine Mammal, Sea Turtle, and Seabird Bycatch in the California Drift Gillnet Fishery: 1990–2015*. La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., M. M. Muto, J. Greenman, K. Wilkinson, D. Lawson, J. Viezbicke, and J. Jannot. (2017b). *Sources of Human-Related Injury and Mortality for U.S. Pacific West Coast Marine Mammal Stock Assessments, 2011–2015* (NOAA Technical Memorandum NMFS-SWFSC-579). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., E. M. Oleson, J. Baker, D. W. Weller, A. R. Lang, K. A. Forney, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell, Jr. (2017c). *U.S. Pacific Marine Mammal Stock Assessments: 2016* (NOAA Technical Memorandum NMFS-SWFSC-561). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., E. M. Oleson, K. A. Forney, J. Baker, J. E. Moore, D. W. Weller, A. R. Lang, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, D. Lynch, L. Carswell, and R. L. Brownell, Jr. (2017d). *U.S. Pacific Marine Mammal Stock Assessments: 2017* (NOAA Technical Memorandum NMFS-SWFSC-602). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell, Jr. (2018a). *U.S. Pacific Marine Mammal Stock Assessments: 2017*. La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell, Jr. (2018b). *U.S. Pacific Draft Marine Mammal Stock Assessments: 2018* (NOAA Technical Memorandum NMFS-SWFSC-XXX). La Jolla, CA: National Marine Fisheries Service, Southwest Fisheries Science Center.

Carroll, A. G., R. Przeslawski, A. Duncan, M. Gunning, and B. Bruce. (2017). A critical review of the potential impacts of marine seismic surveys on fish & invertebrates. *Marine Pollution Bulletin, 114*, 16.

Cascadia Research. (2012). *Record number of blue whales off Washington in December 2011*. Retrieved from http://www.cascadiaresearch.org/washington-state-stranding-response/record-number-blue-whales-sighted-washington-coast-december-2011.

Cascadia Research. (2017a). *Return of humpback whales to the Salish Sea*. Retrieved from http://www.cascadiaresearch.org/projects/return-humpback-whales-salish-sea.

Cascadia Research. (2017b). *"Sounders", the local gray whales that feed in northern Puget Sound each spring, staying longer than usual and update on boat-struck gray whale*. Retrieved from http://www.cascadiaresearch.org/north-puget-sound-gray-whale-study/sounders-update.

Cascadia Research. (2017c). *Examination of fin whale reveals it was killed by collision with ship*. Retrieved from http://www.cascadiaresearch.org/washington-state-stranding-response/examination-fin-whale-reveals-it-was-killed-collision-ship.

Cascadia Research. (2017d). *Puget Sound Bottlenose Dolphin Identified as Part of California Coastal Population*. Retrieved from http://www.cascadiaresearch.org/washington-state/puget-sound-bottlenose-dolphin-identified-part-california-coastal-population.

Cascadia Research Collective. (2011). *Bottlenose dolphin stranding in Puget Sound (February, 2011)*. Retrieved from http://www.cascadiaresearch.org/projects/stranding-response/bottlenose-dolphin-stranding-puget-sound-february-2011.

Castellote, M., C. W. Clark, and M. O. Lammers. (2012). Acoustic and behavioral changes by fin whales (*Balaenoptera physalus*) in responses to shipping and airgun noise. *Biological Conservation, 147*, 115–122.

Castellote, M., T. A. Mooney, L. Quakenbush, R. Hobbs, C. Goertz, and E. Gaglione. (2014). Baseline hearing abilities and variability in wild beluga whales (*Delphinapterus leucas*). *The Journal of Experimental Biology, 217*(Pt 10), 1682–1691.

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.

Cetacean and Turtle Assessment Program. (1982). *Characterization of Marine Mammals and Turtles in the Mid- and North Atlantic Areas of the U.S. Outer Continental Shelf*. Kingston, RI: University of Rhode Island, Graduate School of Oceanography.

Charif, R. A., C. S. Oedekoven, A. Rahaman, B. J. Estabrook, L. Thomas, and A. N. Rice. (2015). *Development of Statistical Methods for Assessing Changes in Whale Vocal Behavior in Response to Mid-Frequency Active Sonar. Final Report*. Virginia Beach, VA: U.S. Fleet Forces Command.

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), 170940.

Christian, E. A., and J. B. Gaspin. (1974). *Swimmer Safe Standards from Underwater Explosions. Navy Science Assistance Program Project No. PHP-11-73*. White Oak, MD: Naval Ordnance Laboratory.

Clapham, P. J. (2016). Managing leviathan: Conservation challenges for the great whales in a post-whaling world. *Oceanography, 29*(3), 214–225.

Claridge, D., D. Charlotte, and J. Durban. (2009). *Abundance and movement patterns of Blainville's beaked whales at the Atlantic Undersea Test and Evaluation Center.* Paper presented at the 2009 Office of Naval Research Marine Mammal Program Review. Alexandria, VA.

Clark, C. W., and K. M. Fristrup. (2001). Baleen whale responses to low-frequency human-made underwater sounds. *The Journal of the Acoustical Society of America, 110*(5), 2751.

Clark, C. W., W. T. Ellison, B. L. Southall, L. Hatch, S. M. Van Parijs, A. Frankel, and D. Ponirakis. (2009). Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. *Marine Ecology Progress Series, 395*, 201–222.

Clark, S. L., and J. W. Ward. (1943). The effects of rapid compression waves on animals submerged in water. *Surgery, Gynecology & Obstetrics, 77*, 403–412.

Cogan, J. (2015). *2015 Whale Sightings in the Salish Sea: Central Salish Sea and Puget Sound* (Southern Resident Killer Whale Project). Friday Harbor, WA: Center for Whale Research.

Condit, R., and B. J. Le Boeuf. (1984). Feeding habits and feeding grounds of the northern elephant seal. *Journal of Mammalogy, 65*(2), 281–290.

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), 1–16.

Cooke, J. G., D. W. Weller, A. L. Bradford, O. Sychenko, A. M. Burdin, A. R. Lang, and R. L. Brownell, Jr. (2015). *Updated Population Assessment of the Sakhalin Gray Whale Aggregation based on the Russia-U.S. photoidentification study at Piltun, Sakhalin, 1994–2014*. Paper presented at the Western Gray Whale Advisory Panel. Moscow, Russia.

Costa, D. P., L. A. Hückstädt, L. K. Schwarz, A. S. Friedlaender, B. R. Mate, A. N. Zerbini, A. Kennedy, and N. J. Gales. (2016a). *Assessing the exposure of animals to acoustic disturbance: Towards an understanding of the population consequences of disturbance.* Paper presented at the Fourth International Conference on the Effects of Noise on Aquatic Life. Dublin, Ireland.

Costa, D. P., L. Schwarz, P. Robinson, R. S. Schick, P. A. Morris, R. Condit, D. E. Crocker, and A. M. Kilpatrick. (2016b). A bioenergetics approach to understanding the population consequences of disturbance: Elephant seals as a model system. In *The Effects of Noise on Aquatic Life II* (pp. 116–169). New York, NY: Springer.

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.

Cox, T. M., T. J. Ragen, A. J. Read, E. Vox, R. W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernandez, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P. D. Jepson, D. Ketten, C. D. MacLeod, P. Miller, S. Moore, D. C. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management, 7*(3), 177–187.

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*, 13–27.

Crum, L., and Y. Mao. (1996). Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. *The Journal of the Acoustical Society of America, 99*(5), 2898–2907.

Crum, L., M. Bailey, J. Guan, P. Hilmo, S. Kargl, and T. Matula. (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.

Cruz-Uribe, O., D. P. Cheney, and G. L. Rorrer. (2007). Comparison of TNT removal from seawater by three marine macroalgae. *Chemsphere, 67*, 1469–1476.

Culik, B. M., S. Koschinski, N. Tregenza, and G. M. Ellis. (2001). Reactions of harbor porpoises *Phocoena phocoena* and herring *Clupea harengus* to acoustic alarms. *Marine Ecological Progress Series, 211*, 255–260.

Culik, B. M. (2004). *Review of Small Cetaceans Distribution, Behaviour, Migration and Threats*. Bonn, Germany: United National Environment Programme and the Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals.

Cummings, W. C., and P. O. Thompson. (1971). Gray whales, *Eschrichtius robustus*, avoid the underwater sounds of killer whales, *Orcinus orca*. *Fishery Bulletin, 69*(3), 525–530.

Cunningham, K. A., B. L. Southall, and C. Reichmuth. (2014). Auditory sensitivity of seals and sea lions in complex listening scenarios. *The Journal of the Acoustical Society of America, 136*(6), 3410–3421.

Cunningham, K. A., and C. Reichmuth. (2015). High-frequency hearing in seals and sea lions. *Hearing Research, 331*, 83–91.

Curé, C., R. Antunes, F. Samarra, A. C. Alves, F. Visser, P. H. Kvadsheim, and P. J. Miller. (2012). Pilot whales attracted to killer whale sounds: Acoustically-mediated interspecific interactions in cetaceans. *PLoS ONE, 7*(12), e52201.

Curé, C., L. D. Sivle, F. Visser, P. J. Wensveen, S. Isojunno, C. M. Harris, P. H. Kvadsheim, F. P. A. Lam, and P. J. O. Miller. (2015). Predator sound playbacks reveal strong avoidance responses in a fight strategist baleen whale. *Marine Ecology Progress Series, 526*, 267–282.

Currie, J. J., S. H. Stack, and G. D. Kaufman. (2017). Modelling whale-vessel encounters: The role of speed in mitigating collisions with humpback whales (*Megaptera novaeangliae*). *Journal of Cetacean and Research Management, 17*, 57–63.

Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. K. Ellifrit, and K. C. Balcomb, III. (2008). Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): Occurrence, movements, and insights into feeding ecology. *Marine Mammal Science, 24*(3), 719–729.

Dahlheim, M. E., P. A. White, and J. M. Waite. (2009). Cetaceans of Southeast Alaska: Distribution and seasonal occurrence. *Journal of Biogeography, 36*(3), 410–426.

Dahlheim, M. E., A. N. Zerbini, J. M. Waite, and A. S. Kennedy. (2015). Temporal changes in abundance of harbor porpoise (*Phocoena phocoena*) inhabiting the inland waters of Southeast Alaska. *Fishery Bulletin, 113*, 242–255.

Dähne, M., V. Peschko, A. Gilles, K. Lucke, S. Adler, K. Ronnenberg, and U. Siebert. (2014). Marine mammals and windfarms: Effects of alpha ventus on harbour porpoises. In *Ecological Research at the Offshore Windfarm alpha ventus* (pp. 133–149). New York, NY: Springer Publishing.

Dähne, M., J. Tougaard, J. Carstensen, A. Rose, and J. Nabe-Nielsen. (2017). Bubble curtains attenuate noise from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises. *Marine Ecology Progress Series, 580*, 221–237.

Dalebout, M. L., J. G. Mead, C. S. Baker, A. N. Baker, and A. L. van Helden. (2002). A new species of beaked whale *Mesoplodon perrini* sp. n. (Cetacea: Ziphiidae) discovered through phylogenetic analyses of mitochondrial DNA sequences. *Marine Mammal Science, 18*(3), 577–608.

Dalla-Rosa, L., J. K. B. Ford, and A. W. Trites. (2012). Distribution and relative abundance of humpback whales in relation to environmental variables in coastal British Columbia and adjacent waters. *Continental Shelf Research, 36*, 89–104.

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.

Darling, J. D., J. Calambokidis, K. C. Balcomb, P. Bloedel, K. Flynn, A. Mochizuki, K. Mori, F. Sato, H. Suganuma, and M. Yamaguchi. (1996). Movement of a humpback whale (*Megaptera Novaeangliae*) from Japan to British Columbia and return. *Marine Mammal Science, 12*(2), 281–287.

Daugherty, A. (2016). *Rare Fin whale spotted in Puget Sound*. Retrieved from http://www.king5.com/article/news/local/pets-and-animals/rare-fin-whale-spotted-in-puget-sound/281-277174294.

Davis, R. W., G. S. Fargion, N. May, T. D. Leming, M. Baumgartner, W. E. Evans, L. J. Hansen, and K. Mullin. (1998). Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. *Marine Mammal Science, 14*(3), 490–507.

De Silva, R., K. Grellier, G. Lye, N. McLean, and P. Thompson. (2014). *Use of population viability analysis to assess the potential for long term impacts from piling noise on marine mammal populations - a case study from the Scottish east coast.* Paper presented at the Proceedings of the 2nd International Conference on Environmental Interactions of Marine Renewable Energy Technologies (EIMR2014). Stornoway. Isle of Lewis, Outer Hebrides, Scotland.

de Soto, N. A. (2016). Peer-Reviewed Studies on the Effects of Anthropogenic Noise on Marine Invertebrates: From Scallop Larvae to Giant Squid. In A. N. Popper & A. Hawkins (Eds.), *The Effects of Noise on Aquatic Life II* (pp. 10). New York, NY: Springer Science.

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*. Honolulu, HI: HDR Inc.

Debich, A. J., S. Baumann-Pickering, A. Širović, J. A. Hildebrand, A. L. Alldredge, R. S. Gottlieb, S. Herbert, S. C. Johnson, L. K. Roche, B. Thayre, J. S. Trickey, and S. M. Wiggins. (2014). *Passive Acoustic Monitoring for Marine Mammals in the Northwest Training Range Complex 2012–2013*. La Jolla, CA: Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego.

Debich, A. J., S. Baumann-Pickering, A. Širović, J. A. Hildebrand, A. L. Alldredge, R. S. Gottlieb, S. T. Herbert, S. C. Johnson, A. C. Rice, L. K. Roche, B. J. Thayre, J. S. Trickey, L. M. Varga, and S. M. Wiggins. (2015). *Passive Acoustic Monitoring for Marine Mammals in the SOCAL Naval Training*

Area Dec 2012–Jan 2014 (MPL Technical Memorandum #552). La Jolla, CA: Marine Physical Laboratory, Scripps Institution of Oceanography.

Deecke, V. B., P. J. B. Slater, and J. K. B. Ford. (2002). Selective habituation shapes acoustic predator recognition in harbour seals. *Nature, 420*(November 14), 171–173.

Defence Science and Technology Laboratory. (2007). *Observations of Marine Mammal Behaviour in Response of Active Sonar*. Salisbury, United Kingdom: Ministry of Defence.

DeLong, R., and S. Jeffries (2017). [Personal communication on pinniped abundance and distribution in the Pacific Northwest in support of the NWTT EIS/OEIS (R. DeLong {National Marine Fisheries Service}, S. Jeffries {Washington Department of Fish and Wildlife}, A. Bella-Holden {U.S. Navy Command Pacific Fleet}, S. Sleeman {U.S. Navy NAVFAC Northwest}, C. Erkelens {Mantech}, and M. Zickel {Mantech})].

DeLong, R. (2018). [Personal Communication with A. Ball-Holden Regarding the Western Stock of Steller Sea Lions in Washington State].

DeLong, R. L., S. J. Jeffries, S. R. Melin, A. J. Orr, and J. L. Laake. (2017). *Satellite Tag Tracking and Behavioral Monitoring of Male California Sea Lions in the Pacific Northwest to Assess Haul-out Behavior on Puget Sound Navy Facilities and Foraging Behavior in Navy Testing and Training Areas*. Seattle, WA: National Marine Fisheries Service and the Washington Department of Fish and Wildlife.

Demarchi, M. W., M. Holst, D. Robichaud, M. Waters, and A. O. MacGillivray. (2012). Responses of Steller sea lions (*Eumetopias jubatus*) to in-air blast noise from military explosions. *Aquatic Mammals, 38*(3), 279.

Deng, Z. D., B. L. Southall, T. J. Carlson, J. Xu, J. J. Martinez, M. A. Weiland, and J. M. Ingraham. (2014). 200 kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. *PLoS ONE, 9*(4), e95315.

Dennison, S., M. J. Moore, A. Fahlman, K. Moore, S. Sharp, C. T. Harry, J. Hoppe, M. Niemeyer, B. Lentell, and R. S. Wells. (2012). Bubbles in live-stranded dolphins. *Proceedings of the Royal Society B: Biological Sciences, 279*(1732), 1396–1404.

DeRuiter, S. L., I. L. Boyd, D. E. Claridge, C. W. Clark, C. Gagon, B. L. Southall, and P. L. Tyack. (2013a). Delphinid whistle production and call matching during playback of simulated military sonar. *Marine Mammal Science, 29*(2), E46–59.

DeRuiter, S. L., B. L. Southall, J. Calambokidis, W. M. Zimmer, D. Sadykova, E. A. Falcone, A. S. Friedlaender, J. E. Joseph, D. Moretti, G. S. Schorr, L. Thomas, and P. L. Tyack. (2013b). First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. *Biology Letters, 9*(4), 20130223.

DeRuiter, S. L., R. Langrock, T. Skirbutas, J. A. Goldbogen, J. Calambokidis, A. S. Friedlaender, and B. L. Southall. (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.

Di Lorio, L., and C. W. Clark. (2010). Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters, 6*, 51–54.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. (1983). *Cetaceans of Central and Northern California, 1980-1983: Status, Abundance, and Distribution* (OCS Study MMS 84–005). Los Angeles, CA: U.S. Department of the Interior, Minerals Management Service, Pacific Outer Continental Shelf Region.

Doksaeter, L., O. R. Godo, N. O. Handegard, P. H. Kvadsheim, F. P. A. Lam, C. Donovan, and P. J. O. Miller. (2009). Behavioral responses of herring (*Clupea harengus*) to 1–2 and 6–7 kHz sonar signals and killer whale feeding sounds. *The Journal of the Acoustical Society of America, 125*(1), 554–564.

Doksaeter, L., N. O. Handegard, O. R. Godo, P. H. Kvadsheim, and N. Nordlund. (2012). Behavior of captive herring exposed to naval sonar transmissions (1.0–1.6 kHz) throughout a yearly cycle. *The Journal of the Acoustical Society of America, 131*(2), 1632–1642.

Dorsey, E. M. (1983). Exclusive adjoining ranges in individually identified minke whales (*Balaenoptera acutorostrata*) in Washington state. *Canadian Journal of Zoology, 61*, 174–181.

Dorsey, E. M., S. J. Stern, A. R. Hoelzel, and J. Jacobsen. (1990). Minke Whales (*Balaenoptera acutorostrata*) from the West Coast of North America: Individual Recognition and Small-Scale Site Fidelity. *Reports of the International Whaling Commission, 12*, 357–368.

Douglas, A. B., J. Calambokidis, S. Raverty, S. J. Jeffries, D. M. Lambourn, and S. A. Norman. (2008). Incidence of ship strikes of large whales in Washington State. *Journal of the Marine Biological Association of the United Kingdom, 88*(6), 1121–1132.

Douglas, A. B., J. Calambokidis, L. M. Munger, M. S. Soldevilla, M. C. Ferguson, A. M. Havron, D. L. Camacho, G. S. Campbell, and J. A. Hildebrand. (2014). Seasonal distribution and abundance of cetaceans off Southern California estimated from CalCOFI cruise data from 2004 to 2008. *Fishery Bulletin, 112*(2–3), 198–220.

Dunlop, R. A., D. H. Cato, and M. J. Noad. (2010). Your attention please: Increasing ambient noise levels elicits a change in communication behaviour in humpback whales (*Megoptera novaeangliae*). *Proceedings of the Royal Society B: Biological Sciences, 277*, 2521–2529.

Dunlop, R. A., M. J. Noad, D. H. Cato, E. Kniest, P. J. Miller, J. N. Smith, and M. D. Stokes. (2013). Multivariate analysis of behavioural response experiments in humpback whales (*Megaptera novaeangliae*). *The Journal of Experimental Biology, 216*(5), 759–770.

Dunlop, R. A., D. H. Cato, and M. J. Noad. (2014). Evidence of a Lombard response in migrating humpback whales (*Megaptera novaeangliae*). *The Journal of the Acoustical Society of America, 136*(1), 430–437.

Dunlop, R. A., M. J. Noad, R. D. McCauley, E. Kniest, D. Paton, and D. H. Cato. (2015). The behavioural response of humpback whales (*Megaptera novaeangliae*) to a 20 cubic inch air gun. *Aquatic Mammals, 41*(4), 412.

Dunlop, R. A., M. J. Noad, R. D. McCauley, E. Kniest, R. Slade, D. Paton, and D. H. Cato. (2016). Response of humpback whales (*Megaptera novaeangliae*) to ramp-up of a small experimental air gun array. *Marine Pollution Bulletin, 103*(1–2), 72–83.

Dunlop, R. A., M. J. Noad, R. D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D. H. Cato. (2017). Determining the behavioural dose-response relationship of marine mammals to air gun noise and source proximity. *The Journal of Experimental Biology, 220*(16), 2878–2886.

Durban, J. W., D. W. Weller, and W. L. Perryman. (2017). *Gray whale abundance estimates from shore-based counts off California in 2014/15 and 2015/16*. Cambridge, United Kingdom: International Whaling Commission.

Edds-Walton, P. L. (1997). Acoustic communication signals of mysticete whales. *Bioacoustics, 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*. (Technical Report 1939). San Diego, CA: SPAWAR Systems Center.

Edgell, T. C., and M. W. Demarchi. (2012). California and Steller sea lion use of major winter haulout in the Salish Sea over 45 years. *Marine Ecological Progress Series, 467*, 253–262.

Edwards, M. H., S. M. Shjegstad, R. Wilkens, J. C. King, G. Carton, D. Bala, B. Bingham, M. C. Bissonnette, C. Briggs, N. S. Bruso, R. Camilli, M. Cremer, R. B. Davis, E. H. DeCarlo, C. DuVal, D. J. Fornari, I. Kaneakua-Pia, C. D. Kelley, S. Koide, C. L. Mah, T. Kerby, G. J. Kurras, M. R. Rognstad, L. Sheild, J. Silva, B. Wellington, and M. V. Woerkom. (2016). The Hawaii undersea military munitions assessment. *Deep Sea Research Part II: Topical Studies in Oceanography, 128*, 4–13.

Elliser, C. R., K. H. MacIver, and M. Green. (2017). Group characteristics, site fidelity, and photo-identification of harbor porpoises, *Phocoena phocoena*, Burrows Pass, Fidalgo Island, Washington. *Marine Mammal Science, 34*(2), 365–384.

Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. (2011). A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conservation Biology, 26*(1), 21–28.

Elorriaga-Verplancken, F. R., G. E. Sierra-Rodriguez, H. Rosales-Nanduca, K. Acevedo-Whitehouse, and J. Sandoval-Sierra. (2016). Impact of the 2015 El Niño-Southern Oscillation on the abundance and foraging habits of Guadalupe fur seals and California sea lions from the San Benito Archipelago, Mexico. *PLoS ONE, 11*(5), e0155034.

Environmental Sciences Group. (2005). *Canadian Forces Maritime Experimental and Test Ranges: Environmental Assessment Update 2005*. Kingston, Canada: Environmental Sciences Group, Royal Military College.

Erbe, C. (2002). Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. *Marine Mammal Science, 18*(2), 394–418.

Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. (2016). Communication masking in marine mammals: A review and research strategy. *Marine Pollution Bulletin, 103*(1–2), 15–38.

Eschmeyer, W. N., and J. D. Fong. (2017). *Catalog of Fishes*. San Francisco, CA: California Academy of Sciences. Retrieved from http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp.

Esperon-Rodriguez, M., and J. P. Gallo-Reynoso. (2012). Analysis of the re-colonization of San Benito Archipelago by Guadalupe fur seals (*Arctocephalus townsendi*). *Latin American Journal of Aquatic Research, 40*(1), 213–223.

Etnier, M. A. (2002). Occurrence of Guadalupe fur seals (*Arctocephalus townsendi*) on the Washington coast over the past 500 years. *Marine Mammal Science, 18*(2), 551–557.

Evans, P. G. H., and L. A. Miller. (2003). *Proceedings of the workshop on active sonar and cetaceans* (European Cetacean Society newsletter, No. 42—Special Issue). Las Palmas, Gran Canaria: European Cetacean Society.

Evenson, J. R., D. Anderson, B. L. Murphie, T. A. Cyra, and J. Calambokidis. (2016). *Disappearance and Return of Harbor Porpoise to Puget Sound: 20 Year Pattern Revealed from Winter Aerial Surveys* (Technical Report). Olympia, WA: Washington Department of Fish and Wildlife, Wildlife Program and Cascadia Research Collective.

Everitt, R. D., C. H. Fiscus, and R. L. DeLong. (1980). *Northern Puget Sound Marine Mammals*. Washington, DC: Office of Environmental Engineering and Technology.

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*, 66–77.

Fahlman, A., S. K. Hooker, A. Olszowka, 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 & Neurobiology, 165*(1), 28–39.

Fahlman, A., S. H. Loring, S. P. Johnson, M. Haulena, A. W. Trites, V. A. Fravel, and W. G. Van Bonn. (2014a). Inflation and deflation pressure-volume loops in anesthetized pinnipeds confirms compliant chest and lungs. *Frontiers in Physiology, 5*(433), 1–7.

Fahlman, A., P. L. Tyack, P. J. O. Miller, and P. H. Kvadsheim. (2014b). How man-made interference might cause gas bubble emboli in deep diving whales. *Frontiers in Physiology, 5*(13), 1–6.

Fair, P. A., A. M. Schaefer, T. A. Romano, G. D. Bossart, S. V. Lamb, and J. S. Reif. (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., G. S. Schorr, A. B. Douglas, J. Calambokidis, E. Henderson, M. F. McKenna, J. Hildebrand, and D. Moretti. (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*, 2631–2640.

Falcone, E. A., B. Diehl, A. Douglas, and J. Calambokidis. (2011). *Photo-Identification of Fin Whales (Balaeanoptera physalus) along the US West Coast, Baja California, and Canada*. Olympia, WA: Cascadia Research Collective.

Falcone, E. A., and G. S. Schorr. (2011). *Distribution and Demographics of Marine Mammals in SOCAL Through Photo-Identification, Genetics, and Satellite Telemetry: A Summary of Surveys Conducted 15 July 2010 – 24 June 2011*. Monterey, CA: Naval Postgraduate School.

Falcone, E. A., and G. S. Schorr. (2012). *Distribution and Demographics of Marine Mammals in SOCAL Through Photo-Identification, Genetics, and Satellite Telemetry: A Summary of Surveys Conducted 1 July 2011 – 15 June 2012*. Monterey, CA: Naval Postgraduate School.

Falcone, E. A., and G. S. Schorr. (2013). *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*. Monterey, CA: Naval Postgraduate School.

Falcone, E. A., and G. S. Schorr. (2014). *Distribution and Demographics of Marine Mammals in SOCAL through Photo-Identification, Genetics, and Satellite Telemetry* (Prepared for Chief of Naval Operations Energy and Environmental Readiness Division: NPS-OC-14-005CR). Monterey, CA: Naval Postgraduate School.

Falcone, E. A., G. S. Schorr, S. L. Watwood, S. L. DeRuiter, A. N. Zerbini, R. D. Andrews, R. P. Morrissey, and D. J. Moretti. (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., R. D. Hill, J. Qvist, R. C. Schneider, M. Guppy, G. C. Liggins, P. W. Hochachka, R. E. Elliott, and W. M. Zapol. (1985). Seal lungs collapse during free diving: Evidence from arterial nitrogen tensions. *Science, 229*, 556–558.

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*. Washington, DC: 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.

Fay, R. R. (1988). *Hearing in Vertebrates: A Psychophysics Databook*. Winnetka, IL: Hill-Fay Associates.

Fay, R. R., and A. N. Popper. (1994). *Comparative Hearing: Mammals*. New York, NY: Springer-Verlag.

Ferguson, M. C. (2005). *Cetacean Population Density in the Eastern Pacific Ocean: Analyzing Patterns With Predictive Spatial Models.* (Unpublished Doctoral Dissertation). University of California, San Diego, La Jolla, CA. Retrieved from http://daytonlab.ucsd.edu.

Ferguson, M. C., J. Barlow, P. Feidler, S. B. Reilly, and T. Gerrodette. (2006). Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. *Ecological Modelling, 193*, 645–662.

Ferguson, M. C., C. Curtice, and J. Harrison. (2015a). Biologically important areas for cetaceans within U.S. waters – Gulf of Alaska region. *Aquatic Mammals (Special Issue), 41*(1), 65–78.

Ferguson, M. C., C. Curtice, J. Harrison, and S. M. Van Parijs. (2015b). Biologically important areas for cetaceans within U.S. waters – Overview and rationale. *Aquatic Mammals (Special Issue), 41*(1), 2–16.

Fernandez, A., J. Edwards, F. Rodriguez, A. Espinosa De Los Monteros, P. Herraez, P. Castro, J. Jaber, V. Martin, and M. Arbelo. (2005). "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. (2006). *Beaked Whale (Ziphius cavirostris) Mass Stranding on Almeria's Coasts in Southern Spain*. Las Palmas, Canary Islands: University of Las Palmas de Gran Canaria.

Fernandez, A., E. Sierra, J. Diaz-Delgado, S. Sacchini, Y. Sanchez-Paz, C. Suarez-Santana, M. Arregui, M. Arbelo, and Y. Bernaldo de Quiros. (2017). Deadly acute decompression sickness in Risso's dolphins. *Scientific Reports, 7*(1), 13621.

Ferrara, G. A., T. M. Mongillo, and L. M. Barre. (2017). *Reducing Disturbance from Vessels to Southern Resident Killer Whales: Assessing the Effectiveness of the 2011 Federal Regulations in Advancing Recovery Goals*. (NOAA Technical Memorandum NMFS-OPR-58). Seattle, WA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service.

Fewtrell, J. L., and R. D. McCauley. (2012). Impact of air gun noise on the behaviour of marine fish and squid. *Marine Pollution Bulletin, 64*(5), 984–993.

Filadelfo, R., J. Mintz, E. Michlovich, A. D'Amico, and D. R. Ketten. (2009a). Correlating military sonar use with beaked whale mass strandings: What do the historical data show? *Aquatic Mammals, 35*(4), 435–444.

Filadelfo, R., Y. K. Pinelis, S. Davis, R. Chase, J. Mintz, J. Wolfanger, P. L. Tyack, D. R. Ketten, and A. D'Amico. (2009b). Correlating whale strandings with Navy exercises off Southern California. *Aquatic Mammals, 35*(4), 445–451.

Finneran, J. J., C. E. Schlundt, D. A. Carder, J. A. Clark, J. A. Young, J. B. Gaspin, and S. H. Ridgway. (2000). Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. *The Journal of the Acoustical Society of America, 108*(1), 417–431.

Finneran, J. J., D. A. Carder, and S. H. Ridgway. (2001). Temporary threshold shift (TTS) in bottlenose dolphins (*Tursiops truncatus*) exposed to tonal signals. *The Journal of the Acoustical Society of America, 110*(5), 2749(A).

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. *The Journal of the Acoustical Society of America, 111*(6), 2929–2940.

Finneran, J. J., D. A. Carder, R. Dear, T. Belting, and S. H. Ridgway. (2003a). Pure-tone audiograms and hearing loss in the white whale (*Delphinapterus leucas*). *The Journal of the Acoustical Society of America, 114*, 2434(A).

Finneran, J. J., R. Dear, D. A. Carder, and S. H. Ridgway. (2003b). Auditory and behavioral responses of California sea lions (*Zalophus californianus*) to single underwater impulses from an arc-gap transducer. *The Journal of the Acoustical Society of America, 114*(3), 1667–1677.

Finneran, J. J., and C. E. Schlundt. (2004). *Effects of Intense Pure Tones on the Behavior of Trained Odontocetes*. San Diego, CA: Space and Naval Warfare Systems Center Pacific.

Finneran, J. J., D. A. Carder, R. Dear, T. Belting, J. McBain, L. Dalton, and S. H. Ridgway. (2005a). Pure tone audiograms and possible aminoglycoside-induced hearing loss in belugas (*Delphinapterus leucas*). *The Journal of the Acoustical Society of America, 117*, 3936–3943.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway. (2005b). Temporary threshold shift (TTS) in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. *The Journal of the Acoustical Society of America, 118*(4), 2696–2705.

Finneran, J. J., and D. S. Houser. (2006). Comparison of in-air evoked potential and underwater behavioral hearing thresholds in four bottlenose dolphins (*Turiops truncatus*). *The Journal of the Acoustical Society of America, 119*(5), 3181–3192.

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. *The Journal of the Acoustical Society of America, 122*(2), 1249–1264.

Finneran, J. J., D. S. Houser, B. Mase-Guthrie, R. Y. Ewing, and R. G. Lingenfelser. (2009). Auditory evoked potentials in a stranded Gervais' beaked whale (*Mesoplodon europaeus*). *The Journal of the Acoustical Society of America, 126*(1), 484–490.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and R. L. Dear. (2010a). Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. *The Journal of the Acoustical Society of America, 127*(5), 3256–3266.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and R. L. Dear. (2010b). Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. *The Journal of the Acoustical Society of America, 127*(5), 3267–3272.

Finneran, J. J., and B. K. Branstetter. (2013). Effects of Noise on Sound Perception in Marine Mammals *Animal Communication and Noise* (Vol. 2, pp. 273–308). Berlin, Germany: Springer Berlin Heidelberg.

Finneran, J. J., and C. E. Schlundt. (2013). Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). *The Journal of the Acoustical Society of America, 133*(3), 1819–1826.

Finneran, J. J. (2015). Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. *The Journal of the Acoustical Society of America, 138*(3), 1702–1726.

Finneran, J. J., C. E. Schlundt, B. K. Branstetter, J. S. Trickey, V. Bowman, and K. Jenkins. (2015). Effects of multiple impulses from a seismic air gun on bottlenose dolphin hearing and behavior. *The Journal of the Acoustical Society of America, 137*(4), 1634–1646.

Finneran, J. J., J. Mulsow, D. S. Houser, and R. F. Burkard. (2016). Place specificity of the click-evoked auditory brainstem response in the bottlenose dolphin (*Tursiops truncatus*). *The Journal of the Acoustical Society of America, 140*(4), 2593–2602.

Finneran, J. J. (2018). Conditioned attenuation of auditory brainstem responses in dolphins warned of an intense noise exposure: Temporal and spectral patterns. *The Journal of the Acoustical Society of America, 143*(2), 795.

Fish, J. F., and J. S. Vania. (1971). Killer whale, *Orcinus orca*, sounds repel white whales, *Delphinapterus leucas*. *Fishery Bulletin, 69*(3), 531–535.

Fisheries and Oceans Canada. (2015). *Recovery Strategy for the Offshore Killer Whale (Orcinus orca) in Canada [Draft]*. Ottawa, Canada: Fisheries and Oceans Canada.

Fitch, R., J. Harrison, and J. Lewandowski. (2011). *Marine Mammal and Sound Workshop July 13th and 14th, 2010: Report to the National Ocean Council Ocean Science and Technology Interagency Policy Committee*. Washington, DC: Bureau of Ocean Energy Management, Department of the Navy, National Oceanic and Atmospheric Administration.

Fleishman, E., D. P. Costa, J. Harwood, S. Kraus, D. Moretti, L. F. New, R. S. Schick, L. K. Schwarz, S. E. Simmons, L. Thomas, and R. S. Wells. (2016). Monitoring population-level responses of marine mammals to human activities. *Marine Mammal Science, 32*(3), 1004–1021.

Foote, A. D., R. W. Osborne, and A. R. Hoelzel. (2004). Whale-call response to masking boat noise. *Nature, 428,* 910.

Ford, J. K. B., and G. M. Ellis. (1999). *Transients: Mammal-Hunting Killer Whales of British Columbia, Washington, and Southeastern Alaska*. Vancouver, Canada and Seattle, WA: UBC Press and University of Washington Press.

Ford, J. K. B., R. M. Abernethy, A. V. Phillips, J. Calambokidis, G. M. Ellis, and L. M. Nichol. (2010). *Distribution and Relative Abundance of Cetaceans in Western Canadian Waters From Ship Surveys, 2002-2008*. Nanaimo, Canada: Fisheries and Oceans Canada, Pacific Biological Station.

Ford, J. K. B., E. H. Stredulinsky, J. R. Towers, and G. M. Ellis. (2013). *Information in Support of the Identification of Critical Habitat for Transient Killer Whales (Orcinus orca) off the West Coast of Canada DFO* (Science Advisory Report 2013/025). Nanaimo, Canada: Canadian Science Advisory Secretariat.

Ford, J. K. B., E. H. Stredulinsky, G. M. Ellis, J. W. Durban, and J. F. Pilkington. (2014). *Offshore Killer Whales in Canadian Pacific Waters: Distribution, Seasonality, Foraging Ecology, Population Status and Potential for Recovery*. (Document 2014/088). Ottawa, Canada: Department of Fisheries and Oceans Canada, Canadian Science Advisory, Secretariat.

Forney, K. A., and J. Barlow. (1998). Seasonal patterns in the abundance and distribution of California cetaceans, 1991–1992. *Marine Mammal Science, 14*(3), 460–489.

Forney, K. A., and P. R. Wade. (2006). Worldwide Distribution and Abundance of Killer Whales. In J. A. Estes, R. L. Brownell, Jr., D. P. DeMaster, D. F. Doak, & T. M. Williams (Eds.), *Whales, Whaling and Ocean Ecosystems* (pp. 145–162). Berkeley, CA: University of California Press.

Forney, K. A. (2007). *Preliminary Estimates of Cetacean Abundance Along the U.S. West Coast and Within Four National Marine Sanctuaries During 2005* (National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SWFSC-406). La Jolla, CA: Southwest Fisheries Science Center.

Forney, K. A., M. C. Ferguson, E. A. Becker, P. C. Fiedler, J. V. Redfern, J. Barlow, I. L. Vilchis, and L. T. Ballance. (2012). Habitat-based spatial models of cetacean density in the eastern Pacific Ocean. *Endangered Species Research, 16*(2), 113–133.

Forney, K. A., E. A. Becker, D. G. Foley, J. Barlow, and E. M. Oleson. (2015). Habitat-based models of cetacean density and distribution in the central North Pacific. *Endangered Species Research, 27*, 1–20.

Forney, K. A., B. L. Southall, E. Slooten, S. Dawson, A. J. Read, R. W. Baird, and R. L. Brownell, Jr. (2017). Nowhere to go: Noise impact assessments for marine mammal populations with high site fidelity. *Endangered Species Research, 32*, 391–413.

Frankel, A. S., and C. W. Clark. (2000). Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. *The Journal of the Acoustical Society of America, 108*(4), 1930–1937.

Frasier, T. R., S. M. Koroscil, B. N. White, and J. D. Darling. (2011). Assessment of population substructure in relation to summer feeding ground use in the eastern North Pacific gray whale. *Endangered Species Research, 14*(1), 39–48.

Friedlaender, A. S., E. L. Hazen, J. A. Goldbogen, A. K. Stimpert, J. Calambokidis, and B. L. Southall. (2016). Prey-mediated behavioral responses of feeding blue whales in controlled sound exposure experiments. *Ecological Applications, 26*(4), 1075–1085.

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. *The Journal of the Acoustical Society of America, 113*(6), 3411–3424.

Fritz, L., K. Sweeney, R. Towell, and T. Gelatt. (2016). *Aerial and Ship-Based Surveys of Stellar Sea Lions (Eumetopias jubatus) Conducted in Alaska in June–July 2013 through 2015, and an Update on the Status and Trend of the Western Distinct Population Segment in Alaska* (National Oceanic and Atmospheric Administration Technical Memorandum NMFS-AFSC-321). Seattle, WA: Alaska Fisheries Science Center.

Fromm, D. M. (2009). *Reconstruction of Acoustic Exposure on Orcas in Haro Strait* (Acoustics). Washington, DC: U.S. Naval Research Laboratory.

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.

Fulling, G. L., T. A. Jefferson, D. Fertl, J. C. S. Vega, C. S. Oedekoven, and S. A. Kuczaj, II. (2017). Sperm Whale (*Physeter macrocephalus*) Collision with a Research Vessel: Accidental Collision or Deliberate Ramming? *Aquatic Mammals, 43*(4), 421–429.

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.

Gailey, G., O. Sychenko, T. McDonald, R. Racca, A. Rutenko, and K. Bröker. (2016). Behavioural responses of western gray whales to a 4-D seismic survey off northeastern Sakhalin Island, Russia. *Endangered Species Research, 30*, 53–71.

Gallo-Reynoso, J. P., and M. Esperón-Rodríguez. (2013). Diet composition of the Guadalupe fur seal (*Arctocephalus townsendi*). Where and what do they eat? *Marine and Freshwater Behaviour and Physiology, 46*(6), 455–467.

Gannier, A., and E. Praca. (2007). SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom, 87*(01), 187.

Garcia-Aguilar, M. C., C. Turrent, F. R. Elorriaga-Verplancken, A. Arias-Del-Razo, and Y. Schramm. (2018). Climate change and the northern elephant seal (*Mirounga angustirostris*) population in Baja California, Mexico. *PLoS ONE, 13*(2), e0193211.

Garcia, M. A., L. Barre, and M. Simpkins. (2016). *The Ecological Role of Marine Mammal-Eating Killer Whales in the North Pacific Ocean Surrounding Alaska*. Bethesda, MD: Marine Mammal Commission.

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).

Gaspin, J. B. (1975). *Experimental Investigations of the Effects of Underwater Explosions on Swimbladder Fish, I: 1973 Chesapeake Bay Tests*. Silver Spring, MD: Naval Surface Weapons Center, White Oak Laboratory.

Gaspin, J. B., G. B. Peters, and M. L. Wisely. (1976). *Experimental Investigations of the Effects of Underwater Explosions on Swimbladder Fish*. Silver Spring, MD: Naval Ordnance Lab.

Gaydos, J. K., L. Ignacio Vilchis, M. M. Lance, S. J. Jeffries, A. Thomas, V. Greenwood, P. Harner, and M. H. Ziccardi. (2013). Post-release movement of rehabilitated harbor seal (*Phoca vitulina richardii*) pups compared with cohort-matched wild seal pups. *Marine Mammal Science, 29*(3), E282–E294.

Gearin, P. J., S. R. Melin, R. L. DeLong, M. E. Gosho, and S. J. Jeffries. (2017). *Migration Patterns of Adult Male California Sea Lions (Zalophus californianus)* (National Oceanic and Atmospheric Administration Technical Memorandum NMFS-AFSC-346). Silver Spring, MD: National Marine Fisheries Service, Alaska Fisheries Science Center.

Gende, S. M., A. N. Hendrix, K. R. Harris, B. Eichenlaub, J. Nielsen, and S. Pyare. (2011). A Bayesian approach for understanding the role of ship speed in whale-ship encounters. *Ecological Applications, 21*(6), 2232–2240.

Geraci, J., J. Harwood, and V. Lounsbury. (1999). Marine Mammal Die-Offs: Causes, Investigations, and Issues. In J. Twiss & R. Reeves (Eds.), *Conservation and Management of Marine Mammals* (pp. 367–395). Washington, DC: Smithsonian Institution Press.

Geraci, J., and V. Lounsbury. (2005). *Marine Mammals Ashore: A Field Guide for Strandings* (Second ed.). Baltimore, MD: National Aquarium in Baltimore.

Ghoul, A., and C. Reichmuth. (2014). Hearing in the sea otter (*Enhydra lutris*): Auditory profiles for an amphibious marine carnivore. *Journal of Comparative Physiology A: Neuroethology, Sensory Neural, and Behavioral Physiology, 200*(11), 967–981.

Gjertz, I., and A. Børset. (1992). Pupping in the most northerly harbor seal (*Phoca vitulina*). *Marine Mammal Science, 8*(2), 103–109.

Goertner, J. F. (1982). *Prediction of Underwater Explosion Safe Ranges for Sea Mammals*. Dahlgren, VA: Naval Surface Weapons Center.

Goertner, J. F., M. L. Wiley, G. A. Young, and W. W. McDonald. (1994). *Effects of Underwater Explosions on Fish Without Swimbladders*. Silver Spring, MD: Naval Surface Warfare Center.

Goldbogen, J. A., B. L. Southall, S. L. DeRuiter, J. Calambokidis, A. S. Friedlaender, E. L. Hazen, E. A. Falcone, G. S. Schorr, A. Douglas, D. J. Moretti, C. Kyburg, M. F. McKenna, and P. L. Tyack. (2013). Blue whales respond to simulated mid-frequency military sonar. *Proceedings of the Royal Society B: Biological Sciences, 280*(1765), 20130657.

Gomez, C., J. W. Lawson, A. J. Wright, A. Buren, D. Tollit, and V. Lesage. (2016). A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy. *Canadian Journal of Zoology, 94*(12), 801–819.

Gong, Z., A. D. Jain, D. Tran, D. H. Yi, F. Wu, A. Zorn, P. Ratilal, and N. C. Makris. (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), e104733.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M. P. Simmonds, R. Swift, and D. Thompson. (2003). A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal, 37*(4), 16–34.

Gosho, M., P. Gearin, R. Jenkinson, J. Laake, L. Mazzuca, D. Kubiak, J. Calambokidis, W. Megill, B. Gisborne, D. Goley, C. Tombach, J. Darling, and V. Deecke. (2011). *Movements and diet of gray whales (Eschrichtius robustus) off Kodiak Island, Alaska, 2002–2005*. Paper presented at the International Whaling Commission AWMP workshop 28 March–1 April 2011. Washington, DC.

Götz, T., and V. M. Janik. (2011). Repeated elicitation of the acoustic startle reflex leads to sensation in subsequent avoidance behaviour and induces fear conditioning. *BMC Neuroscience, 12*(30), 13.

Graham, I. M., E. Pirotta, N. D. Merchant, A. Farcas, T. R. Barton, B. Cheney, G. D. Hastie, and P. M. Thompson. (2017). Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. *Ecosphere, 8*(5), 1–16.

Greaves, F. C., R. H. Draeger, O. A. Brines, J. S. Shaver, and E. L. Corey. (1943). An experimental study of concussion. *United States Naval Medical Bulletin, 41*(1), 339–352.

Green, D. M. (1994). Sound's effects on marine mammals need investigation. *Eos, 75(27)*, 305–306.

Green, D. M., H. DeFerrari, D. McFadden, J. Pearse, A. Popper, W. J. Richardson, S. H. Ridgway, and P. Tyack. (1994). *Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs*. Washington, DC: Ocean Studies Board, Commission on Geosciences, Environment, and Resources, National Research Council.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb, III. (1992). *Cetacean Distribution and Abundance off Oregon and Washington, 1989–1990*. Los Angeles, CA: U.S. Department of the Interior, Minerals Management Service.

Gregr, E. J., L. Nichol, J. K. B. Ford, G. Ellis, and A. W. Trites. (2000). Migration and population structure of northeastern Pacific whales off coastal British Columbia: An analysis of commercial whaling records from 1908–1967. *Marine Mammal Science, 16*(4), 699–727.

Gregr, E. J., and A. W. Trites. (2001). Predictions of critical habitat for five whale species in the waters of coastal British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences, 58*(7), 1265–1285.

Gregr, E. J., J. Calambokidis, L. Convey, J. K. B. Ford, R. I. Perry, L. Spaven, and M. Zacharias. (2006). Recovery Strategy for Blue, Fin, and Sei Whales (*Balaenoptera musculus*, *B. phsalus*, and *B. borealis*) in Pacific Canadian Waters. In *Species at Risk Act Recovery Strategy Series* (pp. 53). Vancouver, Canada: Fisheries and Oceans Canada.

Guan, S., B. L. Southall, J. F. Vignola, J. A. Judge, and D. Turo. (2017). Sonar inter-ping noise field characterization during cetacean behavioral response studies off Southern California. *Acoustical Physics, 63*(2), 204–215.

Guazzo, R. A., T. A. Helble, G. L. D'Spain, D. W. Weller, S. M. Wiggins, and J. A. Hildebrand. (2017). Migratory behavior of eastern North Pacific gray whales tracked using a hydrophone array. *PLoS ONE, 12*(10), e0185585.

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.

Hall, A., K. Hugunin, R. Deaville, R. Law, C. R. Allchin, and P. Jepson. (2006). The Risk of Infection from Polychlorinated Biphenyl Exposure in the Harbor Porpoise (*Phocoena phocoena*): A Case-Control Approach. *Environmental Health Perspectives, 114*, 704–711.

Halpin, L. R., J. R. Towers, and J. K. B. Ford. (2018). First record of common bottlenose dolphin (*Tursiops truncatus*) in Canadian Pacific waters. *Marine Biodiversity Records, 11*(3), 1–5.

Halvorsen, M. B., D. G. Zeddies, W. T. Ellison, D. R. Chicoine, and A. N. Popper. (2012). Effects of mid-frequency active sonar on hearing in fish. *The Journal of the Acoustical Society of America, 131*(1), 599–607.

Hamilton, T. A., J. V. Redfern, J. Barlow, L. T. Ballance, T. Gerrodette, R. S. Holt, K. A. Forney, and B. L. Taylor. (2009). *Atlas of Cetacean Sightings for Southwest Fisheries Science Center Cetacean and Ecosystem Surveys: 1986–2005* (NOAA Technical Memorandum NMFS-SWFSC-440). La Jolla, CA: Southwest Fisheries Science Center.

Hance, A. J., E. D. Robin, J. B. Halter, N. Lewiston, D. A. Robin, L. Cornell, M. Caligiuri, and J. Theodore. (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.

Hanson, M. B., E. J. Ward, C. K. Emmons, M. M. Holt, and D. M. Holzer. (2015). *Using Satellite-tag Locations to Improve Acoustic Detection Data for Endangered Killer Whales near a U.S. Navy Training Range in Washington State*. Pearl Harbor, HI: U.S. Navy, U.S. Pacific Fleet.

Hanson, M. B., E. J. Ward, C. K. Emmons, M. M. Holt, and D. M. Holzer. (2017). *Assessing the Movements and Occurrence of Southern Resident Killer Whales Relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest*. Seattle, WA: Northwest Fisheries Science Center.

Hanson, M. B., E. J. Ward, C. K. Emmons, and M. M. Holt. (2018). *Modeling the occurrence of endangered killer whales near a U.S. Navy Training Range in Washington State using satellite-*

tag locations to improve acoustic detection data. Seattle, WA: Northwest Fisheries Science Center.

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.

Harris, C., and L. Thomas. (2015). *Status and Future of Research on the Behavioral Responses of Marine Mammals to U.S. Navy Sonar* (Centre for Research into Ecological & Environmental Modelling Technical Report 2015-3). St. Andrews, United Kingdom: University of St. Andrews.

Harris, C. M., D. Sadykova, S. L. DeRuiter, P. L. Tyack, P. J. O. Miller, P. H. Kvadsheim, F. P. A. Lam, and L. Thomas. (2015). Dose response severity functions for acoustic disturbance in cetaceans using recurrent event survival analysis. *Ecosphere, 6*(11), art236.

Harwood, J., and S. L. King. (2014). *The Sensitivity of UK Marine Mammal Populations to Marine Renewables Developments*. Submitted to the Natural Environment Research Council (unpublished).

Hastie, G. D., C. Donovan, T. Gotz, and V. M. Janik. (2014). Behavioral responses by grey seals (*Halichoerus grypus*) to high frequency sonar. *Marine Pollution Bulletin, 79*(1-2), 205–210.

Hatch, L. T., C. W. Clark, S. M. Van Parijs, A. S. Frankel, and D. W. Ponirakis. (2012). Quantifying loss of acoustic communication space for right whales in and around a U.S. National Marine Sanctuary. *Conservation Biology, 26*(6), 983–994.

Hawkins, A. D., and A. D. F. Johnstone. (1978). The hearing of the Atlantic salmon, *Salmo salar*. *Journal of Fish Biology, 13*, 655–673.

Hazen, E. L., D. M. Palacios, K. A. Forney, E. A. Howell, E. Becker, A. L. Hoover, L. Irvine, M. DeAngelis, S. J. Bograd, B. R. Mate, H. Bailey, and N. Singh. (2016). WhaleWatch: A dynamic management tool for predicting blue whale density in the California Current. *Journal of Applied Ecology, 54*(5), 1415–1428.

HDR. (2011). *Jacksonville Southeast Anti-Submarine Warfare Integration Training Initiative Marine Species Monitoring Aerial Monitoring Surveys Trip Report, 3–5 December 2010*. Jacksonville, FL: U.S. Navy Marine Species Monitoring Program.

Heffner, R. S., and H. E. Heffner. (1992). Evolution of sound localization in mammals. In *The Evolutionary Biology of Hearing* (pp. 691–715). New York, NY: Springer-Verlag.

Heinis, F., C. A. F. De Jong, and Rijkswaterstaat Underwater Sound Working Group. (2015). *Framework for Assessing Ecological and Cumulative Effects of Offshore Wind Farms: Cumulative Effects of Impulsive Underwater Sound on Marine Mammals* (TNO Report R10335-A). The Hague, Netherlands: Rijkswaterstaat Zee en Delta.

Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. (2017). *Human-Caused Mortality and Injury of NMFS-Managed Alaska Marine Mammal Stocks, 2011–2015* (NOAA Technical Memorandum NMFS-AFSC-354). Seattle, WA: Alaska Fisheries Science Center.

Henderson, E. E., K. A. Forney, J. P. Barlow, J. A. Hildebrand, A. B. Douglas, J. Calambokidis, and W. J. Sydeman. (2014a). Effects of fluctuations in sea-surface temperature on the occurrence of small cetaceans off Southern California. *Fishery Bulletin, 112*(2-3), 159–177.

Henderson, E. E., M. H. Smith, M. Gassmann, S. M. Wiggins, A. B. Douglas, and J. A. Hildebrand. (2014b). Delphinid behavioral responses to incidental mid-frequency active sonar. *The Journal of the Acoustical Society of America, 136*(4), 2003–2014.

Henderson, E. E., R. A. Manzano-Roth, S. W. Martin, and B. Matsuyama. (2015). *Impacts of U.S. Navy Training Events on Beaked Whale Foraging Dives in Hawaiian Waters: Update*. San Diego, CA: Space and Naval Warfare Systems Command Systems Center Pacific.

Henderson, E. E., S. W. Martin, R. Manzano-Roth, and B. M. 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), 549–562.

Hewitt, A., T. Jenkins, T. Ranney, J. Stark, M. Walsh, S. Taylor, M. Walsh, D. Lambert, N. Perron, N. Collins, and R. Karn. (2003). *Estimates for Explosives Residue from the Detonation of Army Munitions*. Hanover, NH: U.S. Army Engineer Research and Development Center: Cold Region Research and Engineering Laboratory.

Heyning, J. E., and J. G. Mead. (2009). Cuvier's beaked whale *Ziphius cavirostris*. In W. F. Perrin, B. Wursig, & J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 294–295). Cambridge, MA: Academic Press.

Hill, M. C., E. M. Oleson, A. D. Ligon, K. K. Martien, F. I. Archer, S. Baumann-Pickering, A. R. Bendlin, L. Dolar, K. P. B. Merkens, A. Milette-Winfree, P. A. Morin, A. Rice, K. M. Robertson, J. S. Trickey, A. C. Ü, A. Van Cise, and S. M. Woodman. (2015). *Cetacean Monitoring in the Mariana Islands Range Complex, 2014*. Honolulu, HI: U.S. Pacific Fleet.

Hill, M. C., A. L. Bradford, A. D. Ligon, A. C. U, J. Rivers, R. K. Uyeyama, R. L. Brownell, Jr., and E. M. Oleson. (2016a). *Are Humpback Whales (Megaptera novaeangliae) Breeding and Calving in the Mariana Islands?* Cambridge, United Kingdom: International Whaling Commission.

Hill, M. C., E. M. Oleson, S. Baumann-Pickering, A. M. VanCise, A. D. Ligon, A. R. Bendlin, A. C. Ü, J. S. Trickey, and A. L. Bradford. (2016b). *Cetacean Monitoring in the Mariana Islands Range Complex, 2015*. Honolulu, HI: U.S. Pacific Fleet Environmental Readiness Office.

Hill, M. C., A. R. Bendlin, A. C. Ü, K. M. Yano, A. L. Bradford, A. D. Ligon, and E. M. Oleson. (2017). *Cetacean Monitoring in the Mariana Islands Range Complex, 2016* (PIFSC Data Report DR-17-002). Honolulu, HI: U.S. Pacific Fleet Environmental Readiness Office.

Hochachka, P. W., G. C. Liggins, G. P. Guyton, R. C. Schneider, K. S. Stanek, W. E. Hurford, R. K. Creasy, D. G. Zapol, and W. M. Zapol. (1995). Hormonal regulatory adjustments during voluntary diving in Weddell seals. *Comparative Biochemistry and Physiology B, 112*, 361–375.

Hoffman, J. I., K. K. Dasmahapatra, W. Amos, C. D. Phillips, and T. S. Gelatt. (2009). Contrasting patterns of genetic diversity at three different genetic markers in a marine mammal metapopulation. *Molecular Ecology, 18*, 2961–2978.

Holst, M., C. Greene, J. Richardson, T. McDonald, K. Bay, S. Schwartz, and G. Smith. (2011a). Responses of pinnipeds to Navy missile launches at San Nicolas Island, California. *Aquatic Animals, 37*(2), 139–150.

Holst, M., C. R. Greene, Jr. , W. J. Richardson, T. L. McDonald, K. Bay, S. J. Schwartz, and G. Smith. (2011b). Responses of Pinnipeds to Navy Missile Launches at San Nicolas Island, California. *Aquatic Animals, 37*(2), 139–150.

Holt, M. M., D. P. Noren, V. Veirs, C. K. Emmons, and S. Veirs. (2008). Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. *The Journal of the Acoustical Society of America, 125*(1), EL27–EL32.

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. *The Journal of the Acoustical Society of America, 130*(5), 3100–3106.

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. *The Journal of Experimental Biology, 218*(Pt 11), 1647–1654.

Holt, M. M., M. B. Hanson, D. A. Giles, C. K. Emmons, and J. T. Hogan. (2017). Noise levels received by endangered killer whales *Orcinus orca* before and after implementation of vessel regulations. *Endangered Species Research, 34*, 15–26.

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 & Neurobiology, 167*(3), 235–246.

Hooker, S. K., A. Fahlman, M. J. Moore, N. A. de Soto, Y. B. de Quiros, A. O. Brubakk, D. P. Costa, A. M. Costidis, S. Dennison, K. J. Falke, A. Fernandez, M. Ferrigno, J. R. Fitz-Clarke, M. M. Garner, D. S. Houser, P. D. Jepson, D. R. Ketten, P. H. Kvadsheim, P. T. Madsen, N. W. Pollock, D. S. Rotstein, T. K. Rowles, S. E. Simmons, W. Van Bonn, P. K. Weathersby, M. J. Weise, T. M. Williams, and P. L. Tyack. (2012). Deadly diving? Physiological and behavioural management of decompression stress in diving mammals. *Proceedings of the Royal Society B: Biological Sciences, 279*(1731), 1041–1050.

Hoover, A. A. (1988). Harbor Seal (*Phoca vitulina)*. In J. W. Lentfer (Ed.), *Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations* (pp. 125–157). Washington, DC: Marine Mammal Commission.

Horwood, J. (1987). *The Sei Whale: Population Biology, Ecology, and Management*. New York, NY: Croom Helm.

Horwood, J. (2009). Sei whale, *Balaenoptera borealis*. In W. F. Perrin, B. Wursig, & J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 1001–1003). Cambridge, MA: Academic Press.

Hotchkin, C., and S. Parks. (2013). The Lombard effect and other noise-induced vocal modifications: Insight from mammalian communication systems. *Biological Reviews of the Cambridge Philosophical Society, 88*(4), 809–824.

Houck, W. J., and T. A. Jefferson. (1999). Dall's Porpoise, *Phocoenoides dalli* (True, 1885). In S. H. Ridgway & R. Harrison (Eds.), *Handbook of Marine Mammals* (Vol. 6, pp. 443–472). San Diego, CA: Academic Press.

Houghton, J., R. W. Baird, C. K. Emmons, and M. B. Hanson. (2015). Changes in the occurrence and behavior of mammal-eating killer whales in Southern British Columbia and Washington State, 1987–2010. *Northwest Science, 89*(2), 154–169.

Houser, D. S., R. Howard, and S. Ridgway. (2001). Can diving-induced tissue nitrogen supersaturation increase the chance of acoustically driven bubble growth in marine mammals? *Journal of Theoretical Biology, 213*, 183–195.

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. *The Journal of Experimental Biology, 213*, 52–62.

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.

Houser, D. S., S. W. Martin, and J. J. Finneran. (2013). Behavioral responses of California sea lions to mid-frequency (3250-3450 Hz) sonar signals. *Marine Environmental Research, 92*, 268–278.

Houser, D. S., and J. Mulsow. (2016). Acoustics. In M. A. Castellini & J. A. E. Mellish (Eds.), *Marine Mammal Physiology: Requisites for Ocean Living* (pp. 245–268). Boca Raton, FL: CRC Press.

Huber, H. R., S. J. Jeffries, R. F. Brown, R. L. DeLong, and G. VanBlaricom. (2001). Correcting aerial survey counts of harbor seals (*Phoca vitulina richardsi*) in Washington and Oregon. *Marine Mammal Science, 17*(2), 276–293.

Huggins, J. L., S. A. Raverty, S. A. Norman, J. Calambokidis, J. K. Gaydos, D. A. Duffield, D. M. Lambourn, J. M. Rice, B. Hanson, K. Wilkinson, S. J. Jeffries, B. Norberg, and L. Barre. (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.

Hui, C. A. (1985). Undersea topography and the comparative distribution of two pelagic cetaceans. *Fishery Bulletin, 83*(3), 472–475.

Huijser, L. A. E., M. Berube, A. A. Cabrera, R. Prieto, M. A. Silva, J. Robbins, N. Kanda, L. A. Pastene, M. Goto, H. Yoshida, G. A. Vikingsson, and P. J. Palsboll. (2018). Population structure of North Atlantic and North Pacific sei whales (*Balaenoptera borealis*) inferred from mitochondrial control region DNA sequences and microsatellite genotypes. *Conservation Genetics, 19*(4), 1007–1024.

Hurford, W. E., P. W. Hochachka, R. C. Schneider, G. P. Guyton, K. S. Stanek, D. G. Zapol, G. C. Liggins, and W. M. Zapol. (1996). Splenic contraction, catecholamine release, and blood volume redistribution during diving in the Weddell seal. *Journal of Applied Physiology, 80*(1), 298–306.

International Union for Conservation of Nature (IUCN). (2012). *Report of the 11th Meeting of the Western Gray Whale Advisory Panel*. Retrieved from https://www.iucn.org/sites/dev/files/wgwap_11_report_eng.pdf.

International Whaling Commission. (2014). *Report of the Workshop on the Rangewide Review of the Population Structure and Status of North Pacific Gray Whales.* Paper presented at the 14th Meeting of the Western Gray Whale Advisory Panel. La Jolla, CA.

International Whaling Commission. (2016). Report of the Scientific Committee. *Journal of Cetacean Research and Management, 17*, 1–92.

Isojunno, S., C. Curé, P. H. Kvadsheim, F. A. Lam, P. L. Tyack, P. Jacobus, P. J. Wensveen, and P. J. O. Miller. (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., and P. J. Chapham. (2012). Soviet catches of right whales (*Eubalaena japonica)* and bowhead whales (*Balaena mysticetus)* in the North Pacific Ocean and the Okhotsk Sea. *Endangered Species Research, 18*, 201–217.

Jefferson, T. A., and B. E. Curry. (1996). Acoustic methods of reducing or eliminating marine mammal-fishery interactions: Do they work? *Ocean & Coastal Management, 31*(1), 41–70.

Jefferson, T. A., M. A. Smultea, and C. E. Bacon. (2014). Southern California Bight marine mammal density and abundance from aerial survey, 2008–2013. *Journal of Marine Animals and Their Ecology, 7*(2), 14–30.

Jefferson, T. A., M. A. Webber, and R. L. Pitman. (2015). *Marine Mammals of the World: A Comprehensive Guide to Their Identification* (2nd ed.). Cambridge, MA: Academic Press.

Jefferson, T. A., M. A. Smultea, S. S. Courbis, and G. S. Campbell. (2016). Harbor porpoise (*Phocoena phocoena*) recovery in the inland waters of Washington: Estimates of density and abundance from aerial surveys, 2013–2015. *Canadian Journal of Zoology, 94*(7), 505–515.

Jefferson, T. A., M. A. Smultea, and K. Ampela. (2017). *Harbor Seals (Phoca vitulina) in Hood Canal: Estimating Density and Abundance to Assess Impacts of Navy Activities. Report of a Workshop Held on 15 and 16 October 2015 at National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration Western Regional Center, 7600 Sand Point Way, NE, Seattle, WA*. Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

Jeffries, S., H. Huber, J. Calambokidis, and J. Laake. (2003). Trends and Status of Harbor Seals in Washington State: 1978–1999. *The Journal of Wildlife Management, 67*(1), 207–218.

Jeffries, S. (2014). *Aerial Surveys of Pinniped Haulout Sites in Pacific Northwest Inland Waters. Final Report* (Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii). Silverdale, WA: Naval Facilities Engineering Command (NAVFAC) Northwest.

Jeffries, S. J., P. J. Gearin, H. R. Huber, D. L. Saul, and D. A. Pruett. (2000). *Atlas of Seal and Sea Lion Haulout Sites in Washington*. Olympia, WA: Washington Department of Fish and Wildlife, Wildlife Science Division.

Jemison, L. A., G. W. Pendleton, L. W. Fritz, K. K. Hastings, J. M. Maniscalco, A. W. Trites, and T. S. Gelatt. (2013). Inter-population movements of Steller sea lions in Alaska with implications for population separation. *PLoS ONE, 8*(8), e70167.

Jensen, A. S., and G. K. Silber. (2004). *Large Whale Ship Strike Database* (NOAA Technical Memorandum NMFS-OPR-25). Silver Spring, MD: National Marine Fisheries Service, Office of Protected Resources.

Jepson, P. D., M. Arbelo, R. Deaville, I. A. R. Patterson, P. Castro, J. R. Baker, E. Degollada, H. M. Ross, P. Herráez, A. M. Pocknell, F. Rodriguez, F. E. Howie, A. Espinosa, R. J. Reid, J. R. Jaber, V. Martin, A. A. Cunningham, and A. Fernandez. (2003). Gas-bubble lesions in stranded cetaceans: Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? *Nature, 425*, 575–576.

Jepson, P. D., P. M. Bennett, R. Deaville, C. R. Allchin, J. R. Baker, and R. J. Law. (2005). 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.

Johnson, C. S., M. W. McManus, and D. Skaar. (1989). Masked tonal hearing thresholds in the beluga whale. *The Journal of the Acoustical Society of America, 85*(6), 2651–2654.

Johnston, D. W. (2002). The effect of acoustic harassment devices on harbour porpoises (*Phocoena phocoena*) in the Bay of Fundy, Canada. *Biological Conservation, 108*, 113–118.

Jones, M. L., and S. L. Swartz. (2009). Gray whale, *Eschrichtius robustus*. In W. F. Perrin, B. Wursig, & J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 503–511). Cambridge, MA: Academic Press.

Jørgensen, R., K. K. Olsen, I. B. Falk-Petersen, and P. Kanapthippilai. (2005). *Investigations of Potential Effects of Low Frequency Sonar Signals on Survival, Development and Behaviour of Fish Larvae and Juveniles*. Tromsø, Norway: University of Tromsø, The Norwegian College of Fishery Science.

Juanes, F., K. Cox, and L. Brennan. (2017). The effect of anthropogenic and biological noise on fish behavior and physiology: A meta-analysis. *The Journal of the Acoustical Society of America, 141*(3862).

Juárez-Ruiz, A., F. R. Elorriaga-Verplancken, X. G. Moreno-Sánchez, S. Aguíniga-García, M. J. Amador-Capitanachi, and C. Gálvez. (2018). Diversification of foraging habits among Guadalupe fur seals from their only well-established breeding colony, Guadalupe Island, Mexico. *Marine Biology, 165*(86), 1–12.

Juhasz, A. L., and R. Naidu. (2007). Explosives: Fate, dynamics, and ecological impact in terrestrial and marine environments. *Reviews of Environmental Contamination and Toxicology, 191*, 163–215.

Kajimura, H. (1984). *Opportunistic Feeding of the Northern Fur Seal, Callorhinus ursinus, in the Eastern North Pacific Ocean and Eastern Bering Sea*. Washington, DC: U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Kane, A. S., J. Song, M. B. Halvorsen, D. L. Miller, J. D. Salierno, L. E. Wysocki, D. Zeddies, and A. N. Popper. (2010). Exposure of fish to high intensity sonar does not induce acute pathology. *Journal of Fish Biology, 76*(7), 1825–1840.

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. *The Journal of the Acoustical Society of America, 118*(5), 3154–3163.

Kastak, D., C. Reichmuth, M. M. Holt, J. Mulsow, B. L. Southall, and R. J. Schusterman. (2007). Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (*Zalophus californianus*). *The Journal of the Acoustical Society of America, 122*(5), 2916–2924.

Kastelein, R., N. Jennings, W. Verboom, D. de Haan, and N. M. Schooneman. (2006). Differences in the response of a striped dolphin *(Stenella coeruleoalba)* and a harbor porpoise *(Phocoena phocoena)* to an acoustic alarm. *Marine Environmental Research, 61*, 363–378.

Kastelein, R. A., H. T. Rippe, N. Vaughan, N. M. Schooneman, W. C. Verboom, and D. de Haan. (2000). The effects of acoustic alarms on the behavior of harbor porpoises (*Phocoena phocoena*) in a floating pen. *Marine Mammal Science, 16*(1), 46–64.

Kastelein, R. A., D. de 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*, 351–371.

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 behaviour of harbour porpoises (*Phocoena phocoena)* in a floating pen. *Marine Environmental Research, 59*, 287–307.

Kastelein, R. A., and P. J. Wensveen. (2008). Effect of two levels of masking noise on the hearing threshold of a harbor porpoise (*Phocoena phocoena*) for a 4.0 kHz signal. *Aquatic Mammals, 34*(4), 420–425.

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. *The 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. *The Journal of the Acoustical Society of America, 132*(5), 3525–3537.

Kastelein, R. A., R. Gransier, L. Hoek, and M. Rambags. (2013a). Hearing frequency thresholds of a harbor porpoise (*Phocoena phocoena*) temporarily affected by a continuous 1.5 kHz tone. *The Journal of the Acoustical Society of America, 134*(3), 2286–2292.

Kastelein, R. A., D. van Heerden, R. Gransier, and L. Hoek. (2013b). Behavioral responses of a harbor porpoise (*Phoceoena phocoena*) to playbacks of broadband pile driving sounds. *Marine Environmental Research, 92*, 206–214.

Kastelein, R. A., L. Hoek, R. Gransier, C. A. F. de Jong, J. M. Terhune, and N. Jennings. (2014a). Hearing thresholds of a harbor porpoise (*Phocoena phocoena*) for playbacks of seal scarer signals, and effects of the signals on behavior. *Hydrobiologia, 756*(1), 89–103.

Kastelein, R. A., L. Hoek, R. Gransier, M. Rambags, and N. Claeys. (2014b). Effect of level, duration, and inter-pulse interval of 1–2 kHz sonar signal exposures on harbor porpoise hearing. *The Journal of the Acoustical Society of America, 136*(1), 412–422.

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. *The 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., R. Gransier, M. A. T. Marijt, and L. Hoek. (2015a). Hearing frequency thresholds of harbor porpoises (*Phocoena phocoena*) temporarily affected by played back offshore pile driving sounds. *The Journal of the Acoustical Society of America, 137*(2), 556–564.

Kastelein, R. A., R. Gransier, J. Schop, and L. Hoek. (2015b). Effects of exposure to intermittent and continuous 6–7 kHz sonar sweeps on harbor porpoise (*Phocoena phocoena*) hearing. *The Journal of the Acoustical Society of America, 137*(4), 1623–1633.

Kastelein, R. A., I. van den Belt, R. Gransier, and T. Johansson. (2015c). Behavioral responses of a harbor porpoise (*Phocoena phocoena*) to 25.5- to 24.5-kHz sonar down-sweeps with and without side bands. *Aquatic Mammals, 41*(4), 400–411.

Kastelein, R. A., I. van den Belt, L. Helder-Hoek, R. Gransier, and T. Johansson. (2015d). Behavioral responses of a harbor porpoise (*Phocoena phocoena*) to 25-kHz FM sonar signals. *Aquatic Mammals, 41*(3), 311–326.

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., L. Helder-Hoek, S. Van de Voorde, S. de Winter, S. Janssen, and M. A. Ainslie. (2018). Behavioral responses of harbor porpoises (*Phocoena phocoena*) to sonar playback sequences of sweeps and tones (3.5-4.1 kHz). *Aquatic Mammals, 44*(4), 389–404.

Kasuya, T., and T. Miyashita. (1997). Distribution of Baird's beaked whales off Japan. *Reports of the International Whaling Commission, 47*, 963–968.

Kasuya, T. (2009). Giant beaked whales *Berardius bairdii* and *B. arnuxii*. In W. F. Perrin, B. Wursig, & J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 498–500). Cambridge, MA: Academic Press.

Keen, E. M., J. Wray, J. F. Pilkington, K. I. Thompson, and C. R. Picard. (2018). Distinct habitat use strategies of sympatric rorqual whales within a fjord system. *Marine Environmental Research, 140*(1), 180–189.

Keevin, T. M., and G. L. Hempen. (1997). *The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts*. St. Louis, MO: U.S. Army Corps of Engineers.

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, 128*, 34–42.

Kenyon, K. W., and F. Wilke. (1953). Migration of the Northern Fur Seal, *Callorhinus ursinus*. *Journal of Mammalogy, 34*(1), 86–98.

Kerosky, S. M., S. Baumann-Pickering, A. Širović, J. S. Buccowich, A. J. Debich, Z. Gentes, R. S. Gottlieb, S. C. Johnson, L. K. Roche, B. Thayre, S. M. Wiggins, and J. A. Hildebrand. (2013). *Passive Acoustic Monitoring for Marine Mammals in the Northwest Training Range Complex 2011–2012*. La Jolla, CA: Marine Physical Laboratory Scripps Institution of Oceanography, University of California San Diego.

Ketten, D. R., J. Lien, and S. Todd. (1993). Blast injury in humpback whale ears: Evidence and implications. *The Journal of the Acoustical Society of America, 94*(3), 1849–1850.

Ketten, D. R. (1998). *Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Its Implications for Underwater Acoustic Impacts*. La Jolla, CA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Ketten, D. R. (2000). Cetacean Ears. In W. Au, A. N. Popper, & R. R. Fay (Eds.), *Hearing by Whales and Dolphins* (1st ed., pp. 43–108). New York, NY: Springer-Verlag.

King, S. L., R. S. Schick, C. Donovan, C. G. Booth, M. Burgman, L. Thomas, and J. Harwood. (2015). An interim framework for assessing the population consequences of disturbance. *Methods in Ecology and Evolution, 6*(10), 1150–1158.

Klinck, H., S. L. Nieukirk, S. Fregosi, K. Klinck, D. K. Mellinger, S. Lastuka, G. B. Shilling, and J. C. Luby. (2015a). *Cetacean Studies on the Quinault Range Site in June 2012: Passive Acoustic Monitoring of Marine Mammals Using Gliders - Results from an Engineering Test. Final Report* (Submitted

to: Naval Facilities Engineering Command Pacific under HDR Environmental, Operations and Construction, Inc.). Honolulu, HI: HDR Inc.

Klinck, H., S. L. Nieukirk, S. Fregosi, K. Klinck, D. K. Mellinger, S. Lastuka, G. B. Shilling, and J. C. Luby. (2015b). *Cetacean Studies on the Mariana Islands Range Complex in September-November 2014: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Final Report*. Honolulu, HI: HDR Inc.

Koide, S., J. A. K. Silva, V. Dupra, and M. Edwards. (2015). 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.

Kooyman, G. L., J. P. Schroeder, D. M. Denison, D. D. Hammond, J. J. Wright, and W. P. Bergman. (1972). Blood nitrogen tensions of seals during simulated deep dives. *American Journal of Physiology, 223*(5), 1016–1020.

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*, 283–290.

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.

Kriete, B. (2007). *Orcas in Puget Sound* (Technical Report 2007-01). Seattle, WA: Puget Sound Nearshore Partnership.

Kruse, S., D. K. Caldwell, and M. C. Caldwell. (1999). Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In S. H. Ridgway & R. Harrison (Eds.), *Handbook of Marine Mammals* (Vol. 6, pp. 183–212). San Diego, CA: Academic Press.

Kryter, K. D., W. D. Ward, J. D. Miller, and D. H. Eldredge. (1965). Hazardous exposure to intermittent and steady-state noise. *The Journal of the Acoustical Society of America, 39*(3), 451–464.

Kujawa, S. G., and M. C. Liberman. (2009). Adding insult to injury: Cochlear nerve degeneration after "temporary" noise-induced hearing loss. *The Journal of Neuroscience, 29*(45), 14077–14085.

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. H., and E. M. Sevaldsen. (2005). *The Potential Impact of 1-8 kHz Active Sonar on Stocks of Juvenile Fish During Sonar Exercises*. Kjeller, Norway: Norwegian Defence Research Establishment.

Kvadsheim, P. H., E. M. Sevaldsen, D. Scheie, L. P. Folkow, and A. S. Blix. (2010). *Effects of Naval Sonar on Seals*. Kjeller, Norway: Norwegian Defense Research Establishment.

Kvadsheim, P. H., P. J. Miller, P. L. Tyack, L. D. Sivle, F. P. Lam, and A. Fahlman. (2012). Estimated Tissue and Blood N_2 Levels and Risk of Decompression Sickness in Deep-, Intermediate-, and Shallow-Diving Toothed Whales during Exposure to Naval Sonar. *Frontiers in Physiology, 3*(Article 125), 125.

Kvadsheim, P. H., S. DeRuiter, L. D. Sivle, J. Goldbogen, R. Roland-Hansen, P. J. O. Miller, F. A. Lam, J. Calambokidis, A. Friedlaender, F. Visser, P. L. Tyack, L. Kleivane, and B. Southall. (2017). Avoidance responses of minke whales to 1-4 kHz naval sonar. *Marine Pollution Bulletin, 121*(1–2), 60–68.

Kyhn, L. A., P. B. Jørgensen, J. Carstensen, N. I. Bech, J. Tougaard, T. Dabelsteen, and J. Teilmann. (2015). Pingers cause temporary habitat displacement in the harbour porpoise *Phocoena phocoena*. *Marine Ecology Progress Series, 526*, 253–265.

Laake, J. L., M. S. Lowry, R. L. DeLong, S. R. Melin, and J. V. Carretta. (2018). Population Growth and Status of California Sea Lions. *Journal of Wildlife Management, 82*(3), 583–595.

Lacy, R. C., R. Williams, E. Ashe, K. C. Balcomb, III, L. J. N. Brent, C. W. Clark, D. P. Croft, D. A. Giles, M. Macduffee, and P. C. Paquet. (2017). Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. *Scientific Reports, 7*(14119), 1–12.

Ladich, F., and A. N. Popper. (2004). Parallel Evolution in Fish Hearing Organs. In G. A. Manley, A. N. Popper, & R. R. Fay (Eds.), *Evolution of the Vertebrate Auditory System, Springer Handbook of Auditory Research* (pp. 95–127). New York, NY: Springer-Verlag.

Ladich, F., and R. R. Fay. (2013). Auditory evoked potential audiometry in fish. *Reviews in Fish Biology and Fisheries, 23*(3), 317–364.

Ladich, F., and T. Schulz-Mirbach. (2016). Diversity in fish auditory systems: One of the riddles of sensory biology. *Frontiers in Ecology and Evolution, 4*, 26.

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.

Lalas, C., and H. McConnell. (2016). Effects of seismic surveys on New Zealand fur seals during daylight hours: Do fur seals respond to obstacles rather than airgun noise? *Marine Mammal Science, 32*(2), 643–663.

Lambourn, D. M., S. J. Jeffries, and H. R. Huber. (2010). *Observations of Harbor Seals in Southern Puget Sound during 2009*. Seattle, WA: Washington Department of Fish and Wildlife.

Lambourn, D. M., S. J. Jeffries, K. Wilkinson, J. Huggins, J. Rice, D. Duffield, and S. A. Raverty. (2012). *2007–2009 Pacific Northwest Guadalupe fur seal (Arctocephalus townsendi) Unusual Mortality Event Summary Report* (Submitted to National Oceanic and Atmospheric Administration UME committee May 2012, manuscript on file).

Lammers, M. O., A. A. Pack, E. G. Lyman, and L. Espiritu. (2013). Trends in collisions between vessels and North Pacific humpback whales (*Megaptera novaeangliae*) in Hawaiian waters (1975–2011). *Journal of Cetacean Resource Management, 13*(1), 73–80.

Lammers, M. O., M. Howe, E. Zang, M. McElligott, A. Engelhaupt, and L. Munger. (2017). Acoustic monitoring of coastal dolphins and their response to naval mine neutralization exercises. *Royal Society Open Science, 4*(12), e170558.

Lander, M. E., T. R. Loughlin, M. G. Logsdon, G. R. VanBlaricom, and B. S. Fadely. (2010). Foraging effort of juvenile Steller sea lions, *Eumetopias jubatus,* with respect to heterogeneity of sea surface temperature. *Endangered Species Research, 10*, 145–158.

Le Boeuf, B. J., D. E. Crocker, D. P. Costa, S. B. Blackwell, P. M. Webb, and D. S. Houser. (2000). Foraging ecology of northern elephant seals. *Ecological Monographs, 70*(3), 353–382.

Leatherwood, S., R. R. Reeves, A. E. Bowles, B. S. Stewart, and K. R. Goodrich. (1984). Distribution, seasonal movements and abundance of Pacific white-sided dolphins in the eastern North Pacific. *Scientific Reports of the Whales Research Institute, 35*, 129–157.

Lemonds, D. W., L. N. Kloepper, P. E. Nachtigall, W. W. Au, S. A. Vlachos, and B. K. Branstetter. (2011). A re-evaluation of auditory filter shape in delphinid odontocetes: Evidence of constant-bandwidth filters. *The Journal of the Acoustical Society of America, 130*(5), 3107–3114.

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.

Leslie, M. S., A. Batibasaga, D. S. Weber, D. Olson, and H. C. Rosenbaum. (2005). First record of Blainville's beaked whale, *Mesoplodon densirostris,* in Fiji. *Pacific Conservation Biology, 11*(4), 302–304.

Lin, H. W., A. C. Furman, S. G. Kujawa, and M. C. Liberman. (2011). Primary neural degeneration in the guinea pig cochlea after reversible noise-induced threshold shift. *Journal of the Association for Research in Otolaryngology, 12*(5), 605–616.

London, J. M., J. M. Ver Hoef, S. J. Jeffries, M. M. Lance, and P. L. Boveng. (2012). Haul-Out Behavior of Harbor Seals (*Phoca vitulina*) in Hood Canal, Washington. *PLoS ONE, 7*(6), e38180.

Loughlin, T. R., and M. A. Perez. (1985). *Mesoplodon stejengeri*. *Mammalian Species, 250*, 1–6.

Lowry, M. S., and K. A. Forney. (2005). Abundance and distribution of California sea lions (*Zalophus californianus*) in central and northern California during 1998 and summer 1999. *Fishery Bulletin, 103*(2), 331–343.

Lowry, M. S., R. Condit, B. Hatfield, S. G. Allen, R. Berger, P. A. Morris, B. J. Le Boeuf, and J. Reiter. (2014). Abundance, distribution, and population growth of the northern elephant seal (*Mirounga angustirostris*) in the United States from 1991 to 2010. *Aquatic Mammals, 40*(1), 20–31.

Lucke, K., U. Siebert, P. A. Lepper, and M. Blanchet. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *The Journal of the Acoustical Society of America, 125*(6), 4060–4070.

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*(5), 704–707.

MacFadyen, A., B. M. Hickey, and W. P. Cochlan. (2008). Influences of the Juan de Fuca Eddy on circulation, nutrients, and phytoplankton production in the northern California Current System. *Journal of Geophysical Research, 113*(C08008), 1–19.

MacLeod, C., W. F. Perrin, R. Pitman, J. Barlow, L. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K. D. Mullin, D. L. Palka, and G. T. Waring. (2006). Known and inferred distributions of beaked whale species (family Ziphiidae; Order Cetacea). *Journal of Cetacean Research and Management, 7*(3), 271–286.

MacLeod, C. D. (2000). Review of the distribution of *Mesoplodon* species (order Cetacea, family Ziphiidae) in the North Atlantic. *Mammal Review, 30*(1), 1–8.

MacLeod, C. D., M. B. Santos, and G. J. Pierce. (2003). Review of data on diets of beaked whales: Evidence of niche separation and geographic segregation. *Journal of the Marine Biological Association of the United Kingdom, 83*, 651–665.

MacLeod, C. D., and A. F. Zuur. (2005). Habitat utilization by Blainville's beaked whales off Great Abaco, northern Bahamas, in relation to seabed topography. *Marine Biology, 147*, 1–11.

MacLeod, C. D., and A. D'Amico. (2006). A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *Journal of Cetacean Research and Management, 7*(3), 211–222.

Madsen, P., M. Johnson, P. Miller, N. Soto, J. Lynch, and P. Tyack. (2006). Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *The Journal of the Acoustical Society of America, 120*(4), 2366–2379.

Madsen, P. T., D. A. Carder, K. Bedholm, and S. H. Ridgway. (2005). Porpoise clicks from a sperm whale nose—Convergent evolution of 130 kHz pulses in toothed whale sonars? *Bioacoustics, 15*, 195–206.

Madson, P. L., B. K. van der Leeuw, K. M. Gibbons, and T. H. Van Hevelingen. (2017). *Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2016*. Cascade Locks, OR: U.S. Army Corps of Engineers.

Mahaffy, S. D., R. W. Baird , D. J. McSweeney, D. L. Webster , and G. S. Schorr. (2015). *Group structure and mating strategies of Cuvier's (Ziphius cavirostris) and Blainville's (Mesoplodon densirostris)*

beaked whales off the island of Hawaii. Paper presented at the Society for Marine Mammalogy 21st Biennial Conference of the Biology of Marine Mammals. San Francisco, CA.

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* (Outer Continental Shelf Environmental Assessment Program, Final Report of Principal Investigators MMS 88-0048). Anchorage, AK: Bolt Beranek, & Newman, Inc.

Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. (1988). Observations of feeding gray whale responses to controlled industrial noise exposure. In W. M. Sackinger, M. O. Jeffries, J. L. Imm, & S. D. Tracey (Eds.), *Port and Ocean Engineering Under Arctic Conditions* (Vol. 2, pp. 55–73). Fairbanks, AK: Geophysical Institute, University of Alaska.

Maloni, M., J. A. Paul, and D. M. Gligor. (2013). Slow steaming impacts on ocean carriers and shippers. *Maritime Economics & Logistics, 15*(2), 151–171.

Maniscalco, J. M., K. Wynne, K. W. Pitcher, M. B. Hanson, S. R. Melin, and S. Atkinson. (2004). The occurrence of California sea lions (*Zalophus californianus*) in Alaska. *Aquatic Mammals, 30*(3), 427–433.

Mann, D., D. Higgs, W. Tavolga, M. Souza, and A. Popper. (2001). Ultrasound detection by clupeiform fishes. *The Journal of the Acoustical Society of America*, 3048–3054.

Mann, D. A., A. N. Popper, and B. Wilson. (2005). Pacific herring hearing does not include ultrasound. *Biology Letters, 1*, 158–161.

Manzano-Roth, R., E. E. Henderson, S. W. Martin, C. Martin, and B. M. 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.

Manzano-Roth, R. A., E. E. Henderson, S. W. Martin, and B. Matsuyama. (2013). *The Impact of a U.S. Navy Training Event on Beaked Whale Dives in Hawaiian Waters. July 2013*. Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

Maravilla-Chavez, M. O., and M. S. Lowry. (1999). Incipient breeding colony of Guadalupe fur seals at Isla Benito del Este, Baja California, Mexico. *Marine Mammal Science, 15*(1), 239–241.

Martin, C. R., S. W. Martin, E. E. Henderson, T. A. Helble, R. A. Manzano-Roth, B. M. Matsuyama, and G. C. Alongi. (2017). *SSC Pacific FY16 annual report on PMRF Marine Mammal Monitoring. Final Report*. San Diego, CA: National Marine Mammal Foundation and Space and Naval Warfare Systems Center Pacific.

Martin, S. W., C. R. Martin, B. M. Matsuyama, and E. E. Henderson. (2015). Minke whales (*Balaenoptera acutorostrata*) respond to navy training. *The Journal of the Acoustical Society of America, 137*(5), 2533–2541.

Mate, B., B. Lagerquist, and L. Irvine. (2010). *Feeding habitats, migration, and winter reproductive range movements derived from satellite-monitored radio tags on eastern North Pacific gray whales*. Washington, DC: International Whaling Commission.

Mate, B. (2013). *Final Report: Offshore Gray Whale Satellite Tagging in the Pacific Northwest*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

Mate, B. R., A. Bradford, G. A. Tsidulko, V. Vertankin, and V. Ilyashenko. (2013). *Late feeding season movements of a western North Pacific gray whale off Sakhalin Island, Russia and subsequent migration into the eastern North Pacific* (Paper SC/63/BRG23). Washington, DC: International Whaling Commission.

Mate, B. R., V. Y. Ilyashenko, A. L. Bradford, V. V. Vertyankin, G. A. Tsidulko, V. V. Rozhnov, and L. M. Irvine. (2015a). Critically endangered western gray whales migrate to the eastern North Pacific. *Biology Letters, 11*(4), 1–4.

Mate, B. R., D. M. Palacios, L. M. Irvine, B. A. Lagerquist, T. Follett, M. H. Winsor, and C. Hayslip. (2015b). *Baleen (Blue & Fin) Whale Tagging in Southern California in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas (SOCAL, NWTRC, GOA); Final Report*. Pearl Harbor, HI: U.S. Pacific Fleet.

Mate, B. R., D. M. Palacios, C. S. Baker, B. A. Lagerquist, L. M. Irvine, T. Follett, D. Steel, C. Hayslip, and M. H. Winsor. (2016). *Baleen (Blue and Fin) Whale Tagging in Southern California in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas. Final Report.* Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific.

Mate, B. R., D. M. Palacios, C. S. Baker, B. A. Lagerquist, L. M. Irvine, T. Follett, D. Steel, C. Hayslip, and M. H. Winsor. (2017). *Baleen Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas Covering the Years 2014, 2015, and 2016. Final Report*. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific.

Matsuoka, K., T. Hakamada, and T. Miyashita. (2014). *Recent sightings of the North Pacific Right (Eubalaena japonica) whales in the western North Pacific based on JARPN and JARPN II surveys (1994 to 2013)*. Cambridge, United Kingdom: Scientific Committee.

McCarthy, E., D. Moretti, L. Thomas, N. DiMarzio, R. Morrissey, S. Jarvis, J. Ward, A. Izzi, and A. Dilley. (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., 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, 38*, 692–706.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. A. McCabe. (2000). *Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals; and Effects of Air-gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid*. Bentley, Australia: Centre for Marine Science and Technology.

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*, 1047–1049.

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 the Acoustical Society of America, 98*(2), 712–721.

McDonald, M. A., J. A. Hildebrand, S. M. Wiggins, D. W. Johnston, and J. J. Polovina. (2009). An acoustic survey of beaked whales at Cross Seamount near Hawaii. *The Journal of the Acoustical Society of America, 125*(2), 624–627.

McHuron, E. A., L. K. Schwarz, D. P. Costa, and M. Mangel. (2018). A state-dependent model for assessing the population consequences of disturbance on income-breeding mammals. *Ecological Modelling, 385*, 133–144.

Mead, J. G., W. A. Walker, and W. J. Houck. (1982). Biological observations on *Mesoplodon carlhubbsi* (Cetacea: Ziphiidae). *Smithsonian Contributions to Zoology, 344*, 1–25.

Mead, J. G. (1989). Beaked whales of the genus *Mesoplodon*. In S. H. Ridgway & R. Harrison (Eds.), *Handbook of Marine Mammals* (Vol. 4, pp. 349–430). San Diego, CA: Academic Press.

Meissner, A. M., F. Christiansen, E. Martinez, M. D. Pawley, M. B. Orams, and K. A. Stockin. (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), e0116962.

Melcón, M. L., A. J. Cummins, S. M. Kerosky, L. K. Roche, S. M. Wiggins, and J. A. Hildebrand. (2012). Blue whales respond to anthropogenic noise. *PLoS ONE, 7*(2).

Melin, S. R., R. L. DeLong, and D. B. Siniff. (2008). The effects of El Niño on the foraging behavior of lactating California sea lions (*Zalophus californianus californianus*) during the nonbreeding season. *Canadian Journal of Zoology, 86*(3), 192–206.

Melin, S. R., J. T. Sterling, R. R. Ream, R. G. Towell, T. Zeppelin, A. J. Orr, B. Dickerson, N. Pelland, and C. E. Kuhn. (2012). *A Tale of Two Stocks: Studies of Northern Fur Seals Breeding at the Northern and Southern Extent of the Range*. (0008-4301; 1480-3283). Seattle, WA: Alaska Fisheries Science Center.

Merrick, R. L., and T. R. Loughlin. (1997). Foraging behavior of adult female and young-of-the-year Steller sea lions in Alaskan waters. *Canadian Journal of Zoology, 75*, 776–786.

Mignucci-Giannoni, A. A. (1998). Zoogeography of cetaceans off Puerto Rico and the Virgin Islands. *Caribbean Journal of Science, 34*(3–4), 173–190.

Mikkelsen, L., L. Hermannsen, K. Beedholm, P. T. Madsen, and J. Tougaard. (2017). Simulated seal scarer sounds scare porpoises, but not seals: Species-specific responses to 12 kHz deterrence sounds. *Royal Society Open Science, 4*(7), 170286.

Miksis, J. L., R. C. Connor, M. D. Grund, D. P. Nowacek, A. R. Solow, and P. L. Tyack. (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., C. S. Watson, and W. P. Covell. (1963). Deafening effects of noise on the cat. *Acta Oto-Laryngologica, Supplement 176*, 1–88.

Miller, P., M. Johnson, P. Madsen, N. Biassoni, M. Quero, and P. Tyack. (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., R. Antunes, A. C. Alves, P. Wensveen, P. Kvadsheim, L. Kleivane, N. Nordlund, F.-P. Lam, S. van IJsselmuide, F. Visser, and P. Tyack. (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* (Technical Report SOI-2011-001). St. Andrews, United Kingdom: Scottish Oceans Institute.

Miller, P. (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., R. N. Antunes, P. J. Wensveen, F. I. Samarra, A. C. Alves, P. L. Tyack, P. H. Kvadsheim, L. Kleivane, F. P. Lam, M. A. Ainslie, and L. Thomas. (2014). Dose-response relationships for the onset of avoidance of sonar by free-ranging killer whales. *The Journal of the Acoustical Society of America, 135*(2), 975–993.

Miller, P. J., P. H. Kvadsheim, F. P. Lam, P. L. Tyack, C. Cure, S. L. DeRuiter, L. Kleivane, L. D. Sivle, I. S. P. van, F. Visser, P. J. Wensveen, A. M. von Benda-Beckmann, L. M. Martin Lopez, T. Narazaki, and S. K. Hooker. (2015). First indications that northern bottlenose whales are sensitive to behavioural disturbance from anthropogenic noise. *Royal Society Open Science, 2*(6), 140484.

Miller, P. J. O., N. Biassoni, A. Samuels, and P. L. Tyack. (2000). Whale songs lengthen in response to sonar. *Nature, 405*(6789), 903.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. M. Waite, and W. L. Perryman. (2009). Distribution and movements of fin whales in the North Pacific Ocean. *Mammal Review, 39*(3), 193–227.

Moberg, G. P., and J. A. Mench. (2000). *The Biology of Animal Stress; Basic Principles and Implications for Animal Welfare*. London, United Kingdom: CAB International.

Mobley, J. R., and A. Milette. (2010). *Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaiian Range Complex in Conjunction with a Navy Training Event, SCC February 16–21, 2010, Final Field Report*. Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

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*. San Diego, CA: HDR Inc.

Mobley, J. R., and A. F. 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, 2012, Final Field Report*. Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

Mobley, J. R., M. A. Smultea, C. E. Bacon, and A. S. 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*. Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

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*. Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

Møller, A. R. (2013). *Hearing: Anatomy, Physiology, and Disorders of the Auditory System*. San Diego, CA: Plural Publishing.

Monnahan, C. C. (2013). *Population Trends of the Eastern North Pacific Blue Whale.* (Unpublished master's thesis). University of Washington, Seattle, WA. Retrieved from http://digital.lib.washington.edu.

Monnahan, C. C., T. A. Branch, K. M. Stafford, Y. V. Ivashchenko, and E. M. Oleson. (2014). Estimating historical eastern North Pacific blue whale catches using spatial calling patterns. *PLoS ONE, 9*(6), e98974.

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.

Montie, E. W., C. A. Manire, and D. A. Mann. (2011). Live CT imaging of sound reception anatomy and hearing measurements in the pygmy killer whale, *Feresa attenuata*. *The Journal of Experimental Biology, 214*, 945–955.

Mooney, T. A., P. E. Nachtigall, M. Breese, S. Vlachos, W. Whitlow, and L. Au. (2009a). Predicting temporary threshold shifts in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration. *The 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.

Mooney, T. A., M. Yamato, and B. K. Branstetter. (2012). *Hearing in Cetaceans: From Natural History to Experimental Biology*. Woods Hole, MA: Woods Hole Oceanographic Institution and the National Marine Mammal Foundation.

Moore, J., and J. Barlow. (2017). *Population Abundance and Trend Estimates for Beaked Whales and Sperm Whales in the California Current from Ship-Based Visual Line-Transect Survey Data, 1991–2014* (National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SWFSC-585). La Jolla, CA: Southwest Fisheries Science Center.

Moore, J. E., and J. Barlow. (2011). Bayesian state-space model of fin whale abundance trends from a 1991–2008 time series of line-transect surveys in the California Current. *Journal of Applied Ecology, 48*(5), 1195–1205.

Moore, J. E., and J. P. Barlow. (2013). Declining abundance of beaked whales (Family Ziphiidae) in the California Current Large Marine Ecosystem. *PLoS ONE, 8*(1), e52770.

Moore, M. J., and G. A. Early. (2004). Cumulative sperm whale bone damage and the bends. *Science, 306*, 2215.

Moore, M. J., A. L. Bogomolni, S. E. Dennison, G. Early, M. M. Garner, B. A. Hayward, B. J. Lentell, and D. S. Rotstein. (2009). Gas bubbles in seals, dolphins, and porpoises entangled and drowned at depth in gillnets. *Veterinary Pathology 46*, 536–547.

Moore, M. J., J. van der Hoop, S. G. Barco, A. M. Costidis, F. M. Gulland, P. D. Jepson, K. T. Moore, S. Raverty, and W. A. McLellan. (2013). Criteria and case definitions for serious injury and death of pinnipeds and cetaceans caused by anthropogenic trauma. *Diseases of Aquatic Organisms, 103*(3), 229–264.

Moran, J. R., S. D. Rice, and S. F. Teerlink. (2009). Humpback whale predation on Pacific herring in southern Lynn Canal: Testing a top-down hypothesis. Juneau, AK: Ted Stevens Marine Research Institute, Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration/National Marine Fisheries Service.

Moreland, E. E., M. F. Cameron, R. P. Angliss, and P. L. Boveng. (2015). Evaluation of a ship–based unoccupied aircraft system (UAS) for surveys of spotted and ribbon seals in the Bering Sea pack ice. *Journal of Unmanned Vehicle Systems, 3*(3), 114–122.

Moretti, D., N. DiMarzio, R. Morrissey, E. McCarthy, and S. Jarvis. (2009). *An opportunistic study of the effect of sonar on marine mammals, marine mammal monitoring on Navy ranges (M3R).* Paper presented at the 2009 ONR Marine Mammal Program Review. Alexandria, VA.

Moretti, D., L. Thomas, T. Marques, J. Harwood, A. Dilley, B. Neales, J. Shaffer, E. McCarthy, L. New, S. Jarvis, and R. Morrissey. (2014). A risk function for behavioral disruption of Blainville's beaked whales (*Mesoplodon densirostris*) from mid-frequency active sonar. *PLoS ONE, 9*(1), e85064.

Muir, J. E., L. Ainsworth, R. Racca, Y. Bychkov, G. Gailey, V. Vladimirov, S. Starodymov, and K. Bröker. (2016). Gray whale densities during a seismic survey off Sakhalin Island, Russia. *Endangered Species Research, 29*(3), 211–227.

Mulsow, J., and C. Reichmuth. (2010). Psychophysical and electrophysiological aerial audiograms of a Steller sea lion (*Eumetopias jubatus*). *The Journal of the Acoustical Society of America, 127*(4), 2692–2701.

Mulsow, J. L., J. J. Finneran, and D. S. Houser. (2011). California sea lion (*Zalophus californianus*) aerial hearing sensitivity measured using auditory steady-state response and psychophysical methods. *The Journal of the Acoustical Society of America, 129*(4), 2298–2306.

Munger, L. M., M. O. Lammers, and W. W. L. Au. (2014). *Passive Acoustic Monitoring for Cetaceans within the Marianas Islands Range Complex. Preliminary Report*. Pearl Harbor, HI: Naval Facilities Engineering Command Pacific.

Munger, L. M., M. O. Lammers, J. N. Oswald, T. M. Yack, and W. W. L. Au. (2015). *Passive Acoustic Monitoring of Cetaceans within the Mariana Islands Range Complex Using Ecological Acoustic Recorders. Final Report*. Pearl Harbor, HI: Naval Facilities Engineering Command Pacific.

Mussi, B., A. Miragliuolo, T. De Pippo, M. C. Gambi, and D. Chiota. (2004). The submarine canyon of Cuma (southern Tyrrhenian Sea, Italy), a cetacean key area to protect. *European Research on Cetaceans, 15*, 178–179.

Muto, M. M. and R. P. Angliss (2015). Draft Alaska Marine Mammal Stock Assessments, 2015. Seattle, WA, National Marine Mammal Laboratory: 189.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. R. Zerbini. (2017). *Alaska Marine Mammal Stock Assessments, 2016* (NOAA Technical Memorandum NMFS-AFSC-323). Seattle, WA: National Marine Mammal Laboratory.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. (2018a). *Alaska Marine Mammal Stock Assessments, 2017* (NOAA Technical Memorandum NMFS-AFSC-378). Seattle, WA: Alaska Fisheries Science Center.

Muto, M. M., V. T. Helker, R. P. Angliss, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. (2018b). *Alaska Marine Mammal Stock Assessments, 2018. Draft*. Seattle, WA: National Marine Fisheries Service, Alaska Fisheries Science Center.

Nabe-Nielsen, J., R. M. Sibly, J. Tougaard, J. Teilmann, and S. Sveegaard. (2014). Effects of noise and by-catch on a Danish harbour porpoise population. *Ecological Modelling, 272*, 242–251.

Nachtigall, P. E., D. W. Lemonds, and H. L. Roitblat. (2000). Psychoacoustic Studies of Dolphin and Whale Hearing. In W. W. L. Au , R. R. Fay, & A. N. Popper (Eds.), *Hearing by Whales and Dolphins* (pp. 330–363). New York, NY: Springer.

Nachtigall, P. E., J. L. Pawloski, and W. W. L. Au. (2003). Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). *The Journal of the Acoustical Society of America, 113*(6), 3425–3429.

Nachtigall, P. E., A. Y. Supin, J. 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), 673–687.

Nachtigall, P. E., A. Y. Supin, M. Amundin, B. Roken, T. Møller, T. A. Mooney, K. A. Taylor, and M. Yuen. (2007). Polar bear, *Ursus maritimus,* hearing measured with auditory evoked potentials. *The Journal of Experimental Biology, 210*(7), 1116–1122.

Nachtigall, P. E., T. A. Mooney, K. A. Taylor, L. A. Miller, M. H. Rasmussen, T. Akamatsu, J. Teilmann, M. Linnenschmidt, and G. A. Vikingsson. (2008). Shipboard Measurements of the Hearing of the White-Beaked Dolphin, *Lagenorhynchus albirostris*. *The Journal of Experimental Biology, 211*, 642–647.

Nachtigall, P. E., A. Y. Supin, A. F. Pacini, and R. A. Kastelein. (2018). Four odontocete species change hearing levels when warned of impending loud sound. *Integrative Zoology, 13*, 2–20.

Nakamura, G., A. Hirose, Y. Kim, M. Akagi, and H. Kato. (2017). *Recent increase in the occurrence of the western gray whales, off the Japanese coast through 1955 to 2017.* Tokyo, Japan: Laboratory of Cetacean Biology, Tokyo University of Marine Science and Technology.

National Marine Fisheries Service. (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)*. Seattle, WA: National Marine Fisheries Service.

National Marine Fisheries Service. (2007). *Conservation Plan for the Eastern Pacific Stock of Northern Fur Seal (Callorhinus ursinus)*. Juneau, AK: National Marine Fisheries Service Protected Resources Division, Alaska Region.

National Marine Fisheries Service. (2013a). *Occurrence of Western Distinct Population Segment Steller Sea Lions East of 144° W. Longitude*. Silver Spring, MD: National Oceanic and Atmospheric Administration.

National Marine Fisheries Service. (2013b). *Final Recovery Plan for the North Pacific Right Whale (Eubalaena japonica)*. Silver Spring, MD: National Marine Fisheries Service, Office of Protected Resources.

National Marine Fisheries Service. (2014). *Reinitiated Biological Opinion on Navy Activities on the Northwest Training Range Complex and NMFS's Issuance of an MMPA Letter of Authorization*. (FPR-2014-9069). Washington, DC: The United States Navy and National Oceanic and Atmospheric Administration's National Marine Fisheries Service.

National Marine Fisheries Service. (2015). *Biological Opinion and Conference Report on Navy NWTT Activities and NMFS' MMPA Incidental Take Authorization*. (PCTS FPR-2015-9110). Silver Spring, MD: Office of Protected Resources.

National Marine Fisheries Service. (2016a). *Steller Sea Lion (Eumetopias jubatus)*. Retrieved from https://www.fisheries.noaa.gov/species/steller-sea-lion.

National Marine Fisheries Service. (2016b). *National Marine Fisheries Service, Alaska Region Occurence of Endangered Species Act (ESA) Listed Humpback Whales off Alaska*. Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service. (2016c). Endangered and Threatened Species; Identification of 14 Distinct Population Segments of the Humpback Whale (*Megaptera novaeangliae*) and Revision of Species-Wide Listing. *Federal Register, 81*(174), 62260–62320.

National Marine Fisheries Service. (2016d). *FAQs: Whale, Dolphin, Seal, and Sea Lion (Marine Mammal) Strandings*. Retrieved from http://www.nmfs.noaa.gov/pr/health/faq.htm (accessed in June 2016).

National Marine Fisheries Service. (2016e). *Southern Resident Killer Whales (Orcinus orca) 5-Year Review: Summary and Evaluation*. Seattle, WA: National Oceanic and Atmospheric Administration, West Coast Region.

National Marine Fisheries Service. (2016f). *Fisheries Interactions and Protected Species Bycatch*. Silver Spring, MD: National Oceanic and Atmospheric Administration.

National Marine Fisheries Service. (2016g). *West Coast Region's Endangered Species Act implementation and considerations about "take" given the September 2016 humpback whale DPS status review and species-wide revision of listings*. Long Beach, CA: Protected Resources Division, West Coast Region.

National Marine Fisheries Service. (2017a). *National Stranding Database Level A files for 2000–2016, Washington and Oregon*. Seattle, WA: National Oceanic and Atmospheric Administration Fisheries, Protected Resources Division West Coast Region.

National Marine Fisheries Service. (2017b). *North Pacific Right Whale (Eubalaena japonica) Five-Year Review: Summary and Evaluation*. Silver Spring, MD: Office of Protected Resources, Alaska Region.

National Marine Fisheries Service. (2018a). *New Boating Safeguards for Killer Whales*. Seattle, WA: National Oceanic and Atmospheric Administration Fisheries, West Coast Region.

National Marine Fisheries Service. (2018b). *Draft Recovery Plan for the Blue Whale (Balaenoptera musculus): Revision*. Silver Spring, MD: National Oceanic and Atmospheric Administration, Office of Protected Resources and West Coast Region.

National Marine Fisheries Service: Northwest Region. (2006). *Designation of Critical Habitat for Southern Resident Killer Whales. Biological Report*. Silver Spring, MD: National Marine Fisheries Service.

National Oceanic and Atmospheric Administration. (2002). *Report of the Workshop on acoustic resonance as a source of tissue trauma in cetaceans*. Silver Spring, MD: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

National Oceanic and Atmospheric Administration. (2010). *National Marine Fisheries Service's Final Biological Opinion for the Proposed Issuance of a United States Coast Guard Permit to the St. George Reef Lighthouse Preservation Society to Maintain the St. George Reef Lighthouse as a*

Private Aid to Navigation and Its Effect on the Federally Threatened Eastern Distinct Population Segment of Steller Sea Lion and Designated Critical Habitat. Silver Spring, MD: National Marine Fisheries Service.

National Oceanic and Atmospheric Administration. (2011). Protective Regulations for Killer Whales in the Northwest Region Under the Endangered Species Act and Marine Mammal Protection Act. *Federal Register, 76*(72), 20870–20890.

National Oceanic and Atmospheric Administration. (2014). *NOAA Fisheries Geographic Information Systems*. Retrieved from https://nauticalcharts.noaa.gov/data/gis-data-and-services.html.

National Oceanic and Atmospheric Administration. (2015a). Takes of marine mammals incidental to specified activities; U.S. Navy training and testing activities in the Mariana Islands Training and Testing Study Area. *Federal Register, 80*(148), 46112–46171.

National Oceanic and Atmospheric Administration. (2015b). Takes of Marine Mammals Incidental to Specified Activities; U.S. Navy Training and Testing Activities in the Northwest Training and Testing Study Area; Final Rule. *Federal Register, 80*(226), 73556–73627.

National Oceanic and Atmospheric Administration Fisheries. (2014). *Southern Resident Killer Whales: 10 Years of Research & Conservation*. Seattle, WA: Northwest Fisheries Science Center West Coast Region.

National Research Council. (2003). *Ocean Noise and Marine Mammals*. Washington, DC: The National Academies Press.

National Research Council. (2005). *Marine Mammal Populations and Ocean Noise*. Washington, DC: The National Academies Press.

National Research Council. (2006). *Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options, Committee on Ecosystem Effects of Fishing: Phase II–Assessments of the Extent of Change and the Implications for Policy*. Washington, DC: National Research Council.

Nedwell, J. R., B. Edwards, A. W. H. Turnpenny, and J. Gordon. (2004). *Fish and Marine Mammal Audiograms: A Summary of Available Information*. Hampshire, United Kingdom: Subacoustech Ltd.

New, L. F., J. Harwood, L. Thomas, C. Donovan, J. S. Clark, G. Hastie, P. M. Thompson, B. Cheney, L. Scott-Hayward, D. Lusseau, and D. Costa. (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.

New, L. F., J. S. Clark, D. P. Costa, E. Fleishman, M. A. Hindell, T. Klanjšček, D. Lusseau, S. Kraus, C. R. McMahon, P. W. Robinson, R. S. Schick, L. K. Schwarz, S. E. Simmons, L. Thomas, P. Tyack, and J. Harwood. (2014). Using short-term measures of behaviour to estimate long-term fitness of southern elephant seals. *Marine Ecology Progress Series, 496*, 99–108.

Nichol, L. M., B. M. Wright, P. O'Hara, and J. K. B. Ford. (2017). Risk of lethal vessel strikes to humpback and fin whales off the west coast of Vancouver Island, Canada. *Endangered Species Research, 32*, 373–390.

Nichol, L. M., R. M. Abernethy, B. M. Wright, S. Heaslip, L. D. Spaven, J. R. Towers, J. F. Pilkington, E. H. Stredulinsky, and J. K. B. Ford. (2018). *Distribution, movements and habitat fidelity patterns of Fin Whales (Balaenoptera physalus) in Canadian Pacific Waters*. Ottawa, Canada: Canadian Science Advisory Secretariat, Fisheries and Oceans Canada.

Nieukirk, S. L., D. K. Mellinger, S. E. Moore, K. Klinck, R. P. Dziak, and J. Goslin. (2012). Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. *The Journal of the Acoustical Society of America, 131*(2), 1102–1112.

Nieukirk, S. L., S. Fregosi, D. K. Mellinger, and H. Klinck. (2016). A complex baleen whale call recorded in the Mariana Trench Marine National Monument. *The Journal of the Acoustical Society of America, 140*(3), EL274.

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.

Norris, T. (2017a). [Personal communication via email between Tenaya Norris (The Marine Mammal Center) and Conrad Erkelens (Mantech International Corporation) on Guadalupe fur seal abundance and distribution].

Norris, T. (2017b). [Updated abundance estimate for Guadalupe fur seals. Personal communication on August 18, 2017, between Tenaya Norris (The Marine Mammal Center) and Michael Zickel (Mantech International) via email].

Norris, T. F., J. Oswald, T. Yack, E. Ferguson, C. Hom-Weaver, K. Dunleavy, S. Coates, and T. Dominello. (2012). *An Analysis of Acoustic Data from the Mariana Islands Sea Turtle and Cetacean Survey (MISTCS)*. Encinitas, CA: Bio-Waves, Inc.

Norris, T. F., K. J. Dunleavy, T. M. Yack, and E. L. Ferguson. (2017). Estimation of minke whale abundance from an acoustic line transect survey of the Mariana Islands. *Marine Mammal Science, 33*(2), 574–592.

Nowacek, D., M. Johnson, and P. Tyack. (2004). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London, 271*(B), 227–231.

Nowacek, D., L. H. Thorne, D. Johnston, and P. Tyack. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review, 37*(2), 81–115.

Nowacek, D. P., F. Christiansen, L. Bejder, J. A. Goldbogen, and A. S. Friedlaender. (2016). Studying cetacean behaviour: New technological approaches and conservation applications. *Animal Behaviour, 120*, 235–244.

Nuka Research & Planning Group, LLC. (2012). *Southeast Alaska Vessel Traffic Study*. Seldovia, AK: Nuka Research & Planning Group, LLC.

O'Keeffe, D. J. (1984). *Guidelines for Predicting the Effects of Underwater Explosions on Swimbladder Fish*. Dahlgren, VA: Naval Surface Weapons Center.

O'Keeffe, D. J., and G. A. Young. (1984). *Handbook on the Environmental Effects of Underwater Explosions*. Silver Spring, MD: U.S. Navy, Naval Surface Weapons Center (Code R14).

Office of the Surgeon General. (1991). Conventional warfare ballistic, blast, and burn injuries. In R. Zajitchuk, Col. (Ed.), *U.S.A. Textbook of Military Medicine*. Washington, DC: Office of the Surgeon General.

Olesiuk, P. F. (2012). *Habitat utilization by northern fur seals (Callorhinus ursinus) in the Northeastern Pacific Ocean and Canada* (Research Document 2012/040). Nanaimo, Canada: Canadian Science Advisory Secretariat.

Oleson, E. M., J. Calambokidis, E. Falcone, G. Schorr, and J. A. Hildebrand. (2009). *Acoustic and visual monitoring for cetaceans along the outer Washington coast*. San Diego, CA: University of California San Diego Scripps Institution of Oceanography and Cascadia Research Collective.

Oleson, E. M., and J. Hildebrand. (2012). *Marine Mammal Demographics Off the Outer Washington Coast and Near Hawaii*. Monterey, CA: U.S. Naval Postgraduate School.

Oleson, E. M., S. Baumann-Pickering, A. Širović, K. P. Merkens, L. M. Munger, J. S. Trickey, and P. Fisher-Pool. (2015). *Analysis of long-term acoustic datasets for baleen whales and beaked whales within the Mariana Islands Range Complex (MIRC) for 2010 to 2013* (Pacific Islands Fisheries Science Center Data Report DR-15-002). Honolulu, HI: Pacific Islands Fisheries Science Center.

Olsen, E., W. P. Budgell, E. Head, L. Kleivane, L. Nøttestad, P. Prieto, M. A. Silva, H. Skov, G. A. Víkingsson, G. Waring, and N. Øien. (2009). First satellite-tracked long-distance movement of a sei whale (*Balaenoptera borealis*) in the North Atlantic. *Aquatic Mammals, 35*(3), 313–318.

Olson, J., and R. W. Osborne. (2017). *Southern Resident Killer Whale Sighting Compilation 1948–2016* (RA133F-12-CQ-0057). Friday Harbor, WA: The Whale Museum and Olympic Natural Resources Center.

Olson, J. K. (2013). *The effect of human exposure on the anti-predatory response of harbor seals (Phoca vitulina).* (Unpublished master's thesis). Western Washington University, Bellingham, WA. Retrieved from http://cedar.wwu.edu/wwuet/291.

Owen, M. A., and A. E. Bowles. (2011). In-air auditory psychophysics and the management of a threatened carnivore, the polar bear (*Ursus maritimus)*. *International Journal of Comparative Psychology, 24*, 244–254.

Panigada, S., M. Zanardelli, M. Mackenzie, C. Donovan, F. Melin, and P. S. Hammond. (2008). Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables. *Remote Sensing of Environment, 112*(8), 3400–3412.

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.

Pavlostathis, S. G., and G. H. Jackson. (2002). Biotransformation of 2, 4, 6-trinitrotoluene in a continuous-flow *Anabaena* sp. system. *Water Research, 36*, 1699–1706.

Payne, P. M., and D. W. Heinemann. (1993). The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the northeastern United States, 1978–1988. *Reports of the International Whaling Commission, 14*, 51–68.

Payne, R., and D. Webb. (1971). Orientation by means of long range signaling in baleen whales. *Annals of the New York Academy of Sciences, 188*, 110–141.

Pelland, N. A., J. T. Sterling, M.-A. Lea, N. A. Bond, R. R. Ream, C. M. Lee, and C. C. Eriksen. (2015). Fortuitous Encounters between Seagliders and Adult Female Northern Fur Seals (*Callorhinus ursinus*) off the Washington (USA) Coast: Upper Ocean Variability and Links to Top Predator Behavior. *PLoS ONE, 9*(8), e101268.

Perrin, W. F., and J. R. Geraci. (2002). Stranding. In W. F. Perrin, B. Wursig, & J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (pp. 1192–1197). San Diego, CA: Academic Press.

Perryman, W. L., D. W. Weller, and J. W. Durban. (2017). *Estimates of Eastern North Pacific Gray Whale Calf Projection 1994–2016*. Cambridge, United Kingdom: International Whaling Commission.

Peterson, S. H., M. M. Lance, S. J. Jeffries, and A. Acevedo-Gutiérrez. (2012). Long Distance Movements and Disjunct Spatial Use of Harbor Seals (*Phoca vitulina*) in the Inland Waters of the Pacific Northwest. *PLoS ONE, 7*(6), e39046.

Peterson, S. H., J. T. Ackerman, and D. P. Costa. (2015). Marine foraging ecology influences mercury bioaccumulation in deep-diving northern elephant seals. *Proceedings of the Royal Society B: Biological Sciences, 282*(20150710), 10.

Piantadosi, C. A., and E. D. Thalmann. (2004). Whales, sonar and decompression sickness. *Nature, 425*, 575–576.

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., J. Harwood, P. M. Thompson, L. New, B. Cheney, M. Arso, P. S. Hammond, C. Donovan, and D. Lusseau. (2015a). Predicting the effects of human developments on individual dolphins to understand potential long-term population consequences. *Proceedings of the Royal Society B: Biological Sciences, 282*(1818), 20152109.

Pirotta, E., N. D. Merchant, P. M. Thompson, T. R. Barton, and D. Lusseau. (2015b). Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. *Biological Conservation, 181*, 82–89.

Pirotta, E., M. Mangel, D. P. Costa, B. Mate, J. A. Goldbogen, D. M. Palacios, L. A. Hückstädt, E. A. McHuron, L. Schwarz, and L. New. (2018). A Dynamic State Model of Migratory Behavior and Physiology to Assess the Consequences of Environmental Variation and Anthropogenic Disturbance on Marine Vertebrates. *The American Naturalist, 191*(2), 17.

Piscitelli, M. A., W. A. McLellan, A. S. Rommel, J. E. Blum, S. G. Barco, and D. A. Pabst. (2010). Lung size and thoracic morphology in shallow and deep-diving cetaceans. *Journal of Morphology, 271*, 654–673.

Pitcher, K. W., P. F. Olesiuk, R. F. Brown, M. S. Lowry, S. J. Jeffries, J. L. Sease, W. L. Perryman, C. E. Stinchcomb, and L. F. Lowry. (2007). Abundance and distribution of the eastern North Pacific Steller sea lion (*Eumetopias jubatus*) population. *Fisheries Bulletin, 107*, 102–115.

Pitman, R. L., and M. S. Lynn. (2001). Biological observations of an unidentified mesoplodont whale in the eastern tropical Pacific and probable identity: *Mesoplodon peruvianus*. *Marine Mammal Science, 17*(3), 648–657.

Polovina, J. J., E. Howell, D. R. Kobayashi, and M. P. Seki. (2001). The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. *Progress in Oceanography, 49*, 469–483.

Pomeroy, P., L. O'Connor, and P. Davies. (2015). Assessing use of and reaction to unmanned aerial systems in gray and harbor seals during breeding and molt in the UK. *Journal of Unmanned Vehicle Systems, 3*(3), 102–113.

Popov, V. V., A. Y. Supin, D. Wang, K. Wang, L. Dong, and S. Wang. (2011). Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises, *Neophocaena phocaenoides asiaeorientalis*. *The Journal of the Acoustical Society of America, 130*(1), 574–584.

Popov, V. V., A. Y. Supin, V. V. Rozhnov, D. I. Nechaev, E. V. Sysuyeva, V. O. Klishin, M. G. Pletenko, and M. B. Tarakanov. (2013). Hearing threshold shifts and recovery after noise exposure in beluga whales, *Delphinapterus leucas*. *The Journal of Experimental Biology, 216*(9), 1587–1596.

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*. *The Journal of Experimental Biology, 217*(Pt 10), 1804–1810.

Popper, A. N. (2003). Effects of anthropogenic sounds on fishes. *Fisheries, 28*(10), 24–31.

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. MacGillivray, M. E. Austin, and D. A. Mann. (2005). Effects of exposure to seismic airgun use on hearing of three fish species. *The Journal of the Acoustical Society of America, 117*(6), 3958–3971.

Popper, A. N., M. B. Halvorsen, A. Kane, D. L. Miller, M. E. Smith, J. Song, P. Stein, and L. E. Wysocki. (2007). The effects of high-intensity, low-frequency active sonar on rainbow trout. *The Journal of the Acoustical Society of America, 122*(1), 623–635.

Popper, A. N., and M. C. Hastings. (2009). The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology, 75*(3), 455–489.

Popper, A. N., and R. R. Fay. (2010). Rethinking sound detection by fishes. *Hearing Research, 273*(1–2), 25–36.

Popper, A. N., A. D. Hawkins, R. R. Fay, D. A. Mann, S. M. Bartol, T. J. Carlson, S. Coombs, W. T. Ellison, R. L. Gentry, M. B. Halvorsen, S. Løkkeborg, P. H. Rogers, B. L. Southall, D. G. Zeddies, and W. N. Tavolga. (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*. New York, NY and London, United Kingdom: Acoustical Society of America Press and Springer Briefs in Oceanography.

Popper, A. N., and A. Hawkins. (2016). *The Effects of Noise on Aquatic Life II*. New York, NY: Spring Science+Business Media.

Potter, J. R., M. Thillet, C. Douglas, M. A. Chitre, Z. Doborzynski, and P. J. Seekings. (2007). Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. *IEEE Journal of Oceanic Engineering, 32*(2), 469–483.

Price, S. (2017). *Rare right whale sightings in Southern California*. Retrieved from http://www.cbs8.com/story/36621032/rare-right-whale-sightings-in-southern-california.

Quick, N., L. Scott-Hayward, D. Sadykova, D. Nowacek, and A. Read. (2017). Effects of a scientific echo sounder on the behavior of short-finned pilot whales (*Globicephala macrorhynchus*). *Canadian Journal of Fisheries and Aquatic Sciences, 74*(5), 716–726.

Raum-Suryan, K. L., M. J. Rehberg, G. W. Pendleton, K. W. Pitcher, and T. S. Gelatt. (2004). Development of Dispersal, Movement Patterns, and Haul-Out Use by Pup and Juvenile Steller Sea Lions (*Eumetopias jubatus*) in Alaska. *Marine Mammal Science, 20*(4), 823–850.

Read, A., P. Drinker, and S. Northridge. (2006). Bycatch of marine mammals in U.S. and global fisheries. *Conservation Biology, 20*(1), 163–169.

Read, A. J., S. Barco, J. Bell, D. L. Borchers, M. L. Burt, E. W. Cummings, J. Dunn, E. M. Fougeres, L. Hazen, L. E. W. Hodge, A.-M. Laura, R. J. McAlarney, P. Nilsson, D. A. Pabst, C. G. M. Paxton, S. Z. Schneider, K. W. Urian, D. M. Waples, and W. A. McLellan. (2014). Occurrence, distribution, and abundance of cetaceans in Onslow Bay, North Carolina, USA. *Journal of Cetacean Research and Management, 14*, 23–35.

Ream, R. R., J. T. Sterling, and T. R. Loughlin. (2005). Oceanographic features related to northern fur seal migratory movements. *Deep-Sea Research II, 52*, 823–843.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and J. A. Powell. (2002). *National Audubon Society Guide to Marine Mammals of the World*. New York, NY: Alfred A. Knopf.

Reeves, R. R., and T. D. Smith. (2010). Commercial Whaling, Especially for Gray Whales, *Eschrichtius robustus*, and Humpback Whales, *Megaptera novaeangliae*, at California and Baja California Shore Stations in the 19th Century (1854–1899). *Marine Fisheries Review, 72*(1), 1–25.

Reichmuth, C., M. M. Holt, J. Mulsow, J. M. Sills, and B. L. Southall. (2013). Comparative assessment of amphibious hearing in pinnipeds. *Journal of Comparative Physiology A: Neuroethology, Sensory Neural, and Behavioral Physiology, 199*(6), 491–507.

Rice, A., V. B. Deecke, J. K. B. Ford, J. F. Pilkington, E. M. Oleson, J. A. Hildebrand, and A. Širović. (2017). Spatial and temporal occurrence of killer whale ecotypes off the outer coast of Washington State, USA. *Marine Ecology Progress Series, 572*, 255–268.

Rice, D. W. (1989). Sperm whale *Physeter macrocephalus* Linnaeus, 1758. In S. H. Ridgway & R. Harrison (Eds.), *Handbook of Marine Mammals* (Vol. 4, pp. 177–234). San Diego, CA: Academic Press.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson. (1995). *Marine Mammals and Noise*. San Diego, CA: Academic Press.

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. *The Journal of the Acoustical Society of America, 106*(4), 2281.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher. (1973). *Far-Field Underwater-Blast Injuries Produced by Small Charges*. Washington, DC: Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency.

Rick, T. C., R. L. DeLong, J. M. Erlandson, T. J. Braje, T. L. Jones, D. J. Kennett, T. A. Wake, and P. L. Walker. (2009). A trans-Holocene archaeological record of Guadalupe fur seals (*Arctocephalus townsendi*) on the California coast. *Marine Mammal Science, 25*(2), 487–502.

Ridgway, S. H. (1972). Homeostasis in the Aquatic Environment. In S. H. Ridgway (Ed.), *Mammals of the Sea: Biology and Medicine* (pp. 590–747). Springfield, IL: Charles C. Thomas.

Ridgway, S. H., and R. Howard. (1979). Dolphin lung collapse and intramuscular circulation during free diving: Evidence from nitrogen washout. *Science, 206*, 1182–1183.

Ridgway, S. H., D. A. Carder, R. R. Smith, T. Kamolnick, C. E. Schlundt, and W. R. Elsberry. (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*. (Technical Report 1751, Revision 1). San Diego, CA: U.S. Department of Navy, Naval Command, Control and Ocean Surveillance Center, Research, Development, Test, and Evaluation Division.

Risch, D., P. J. Corkeron, W. T. Ellison, and S. M. Van Parijs. (2012). Changes in humpback whale song occurrence in response to an acoustic source 200 km away. *PLoS ONE, 7*(1), e29741.

Ritter, F. (2012). *Collisions of Sailing Vessels with Cetaceans Worldwide: First Insights into a Seemingly Growing Problem* (SC/61/BC 1). Berlin, Germany: Mammals Encounters Education Research e.V.

Robertson, F. C. (2014). *Effects of Seismic Operations on Bowhead Whale Behavior: Implications for Distribution and Abundance Assessments.* (Unpublished doctoral dissertation). The University of British Columbia, Vancouver, Canada. Retrieved from http://www.marinemammal.org/wp-content/pdfs/Robertson_2014.pdf.

Robinson, P. W., D. P. Costa, D. E. Crocker, J. P. Gallo-Reynoso, C. D. Champagne, M. A. Fowler, C. Goetsch, K. T. Goetz, J. L. Hassrick, L. A. Huckstadt, C. E. Kuhn, J. L. Maresh, S. M. Maxwell, B. I. McDonald, S. H. Peterson, S. E. Simmons, N. M. Teutschel, S. Villegas-Amtmann, and K. Yoda. (2012). Foraging behavior and success of a mesopelagic predator in the northeast Pacific Ocean: Insights from a data-rich species, the northern elephant seal. *PLoS ONE, 7*(5), e36728.

Rocha, R. C., P. J. J. Clapham, and Y. V. Ivashchenko. (2014). Emptying the Oceans: A Summary of Industrial Whaling Catches in the 20th Century. *Marine Fisheries Review, 76*(4), 37–48.

Rockwood, R. C., J. Calambokidis, and J. Jahncke. (2017). High mortality of blue, humpack and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. *PLoS ONE, 12*(8), e0183052.

Rolland, R. M., S. E. Parks, K. E. Hunt, M. Castellote, P. J. Corkeron, D. P. Nowacek, S. K. Wasser, and S. D. Kraus. (2012). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B: Biological Sciences, 279*(1737), 2363–2368.

Romano, T. A., M. J. Keogh, C. Kelly, P. Feng, L. Berk, C. E. Schlundt, D. A. Carder, and J. J. Finneran. (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposures. *Canadian Journal of Fisheries and Aquatic Sciences, 61*, 1124–1134.

Rone, B. K., A. N. Zerbini, A. B. Douglas, D. W. Weller, and P. J. Clapham. (2017). Abundance and distribution of cetaceans in the Gulf of Alaska. *Marine Biology, 164*(23), 1–23.

Rosen, G., and G. R. Lotufo. (2010). Fate and effects of composition B in multispecies marine exposures. *Environmental Toxicology and Chemistry, 29*(6), 1330–1337.

Rosowski, J. J. (1994). Outer and Middle Ears. In R. R. Fay & A. N. Popper (Eds.), *Comparative Hearing: Mammals* (pp. 172–247). Berlin, Germany: Springer-Verlag.

Saez, L., D. Lawson, M. DeAngelis, E. Petras, S. Wilkin, and C. Fahy. (2013). *Understanding the Co-Occurrence of Large Whales and Commercial Fixed Gear Fisheries Off the West Coast of the United States* (NOAA Technical Memorandum NMFS-SWR-044). Long Beach, CA: Southwest Regional Office, Protected Resources Division.

Sanino, G. P., J. L. Yanez, and K. Van Waerebeek. (2007). A first confirmed specimen record in Chile, and sightings attributed to the lesser beaked whale, *Mesoplodon peruvianus* Reyes, Mead and Van Waerebeek, 1991. *Boletin del Museo Nacional de Historia Natural, Chile, 56*, 89–96.

Saunders, K. J., P. R. White, and T. G. Leighton. (2008). Models for Predicting Nitrogen Tensions and Decompression Sickness Risk in Diving Beaked Whales. *Proceedings of the Institute of Acoustics, 30*(5), 1–8.

Scammon, C. M. (1874). *Marine Mammals of the North-western Coast of North America Together with an account of the American Whale-Fishery*. San Francisco, CA: John H. Carmany and Company.

Scarff, J. E. (1991). Historic Distribution and Abundance of the Right Whale (*Eubalaena glacialis*) in the North Pacific, Bering Sea, Sea of Okhotsk and Sea of Japan from the Maury Whale Charts. *Report of the International Whaling Commision, 41*, 467–489.

Scarff, J. E. (2001). Preliminary estimates of whaling-induced mortality in the 19th century North Pacific right whale (*Eubalaena japonicus*) fishery, adjusting for struck-but-lost whales and non-American whaling. *Journal of Cetacean and Research Management, 2*, 261–268.

Schakner, Z. A., and D. T. Blumstein. (2013). Behavioral biology of marine mammal deterrents: A review and prospectus. *Biological Conservation, 167*, 380–389.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. *The Journal of the Acoustical Society of America, 107*(6), 3496–3508.

Schlundt, C. E., R. L. Dear, L. Green, D. S. Houser, and J. J. Finneran. (2007). Simultaneously measured behavioral and electrophysiological hearing thresholds in a bottlenose dolphin (*Tursiops truncatus*). *The Journal of the Acoustical Society of America, 122*(1), 615–622.

Schorr, G. S., E. A. Falcone, D. J. Moretti, and R. D. Andrews. (2014). First long-term behavioral records from Cuvier's beaked whales (*Ziphius cavirostris*) reveal record-breaking dives. *PLoS ONE, 9*(3), e92633.

Schorr, G. S., E. A. Falcone, and B. K. Rone. (2017). *Distribution and Demographics of Cuvier's Beaked Whales and Fin Whales in the Southern California Bight* (Annual report for on-water surveys conducted in conjunction with Marine Mammal Monitoring on Navy Ranges). Seabeck, WA: Marine Ecology and Telemetry Research.

Scordino, J. J., M. Gosho, P. J. Gearin, A. Akamajian, J. Calambokidis, and N. Wright. (2017). Individual gray whale use of coastal waters off northwest Washington during the feeding season 1984–2011: Implications for management. *Journal of Cetacean Research and Management, 16*, 57–69.

Seely, E., R. W. Osborne, K. Koski, and S. Larson. (2017). Soundwatch: Eighteen years of monitoring whale watch vessel activities in the Salish Sea. *PLoS ONE, 12*(12), e0189764.

Shelden, K. E. W., S. E. Moore, J. M. Waite, P. R. Wade, and D. J. Rugh. (2005). Historic and current habitat use by North Pacific right whales *Eubalaena japonica* in the Bering Sea and Gulf of Alaska. *Mammal Review, 35*(2), 129–155.

Shields, M. W., S. Hysong-Shimazu, J. C. Shields, and J. Woodruff. (2018a). Increased presence of mammal-eating killer whales in the Salish Sea with implications for predatory-prey dynamics. *PeerJ, 6*, e6026.

Shields, M. W., J. Lindell, and J. Woodruff. (2018b). Declining spring usage of core habitat by endangered fish-eating killer whales reflects decreased availability of their primary prey. *Pacific Conservation Biology, 24*, 189–193.

Sigler, M. F., S. M. Gende, and D. J. Csepp. (2017). Association of foraging Steller sea lions with persistent prey hot spots in southeast Alaska. *Marine Ecological Progress Series, 571*, 233–243.

Silber, G., J. Slutsky, and S. Bettridge. (2010). Hydrodynamics of a ship/whale collision. *Journal of Experimental Marine Biology and Ecology, 391*, 10–19.

Sills, J. M., B. L. Southall, and C. Reichmuth. (2017). The influence of temporally varying noise from seismic air guns on the detection of underwater sounds by seals. *The Journal of the Acoustical Society of America, 141*(2), 996–1008.

Simmons, S. E., D. E. Crocker, R. M. Kudela, and D. P. Costa. (2007). Linking foraging behaviour of the northern elephant seal with oceanography and bathymetry at mesoscales. *Marine Ecological Progress Series, 346*, 265–275.

Simpkins, M., D. Withrow, J. Cesarone, and P. Boveng. (2003). Stability in the proportion of harbor seals hauled out under locally ideal conditions. *Marine Mammal Science, 19*(4), 791–805.

Singh, R., P. Soni, P. Kumar, S. Purohit, and A. Singh. (2009). Biodegradation of high explosive production effluent containing RDX and HMX by denitrifying bacteria. *World Journal of Microbiology and Biotechnology, 25*, 269–275.

Širović, A., J. A. Hildebrand, S. M. Wiggins, M. A. McDonald, S. E. Moore, and D. Thiele. (2004). Seasonality of blue and fin whale calls and the influence of sea ice in the Western Antarctic Peninsula. *Deep Sea Research II, 51*(17–19), 2327–2344.

Širović, A., J. A. Hildebrand, and S. M. Wiggins. (2007). Blue and fin whale call source levels and propagation range in the Southern Ocean. *The Journal of the Acoustical Society of America, 122*(2), 1208–1215.

Širović, A., J. A. Hildebrand, S. Baumann-Pickering, J. Buccowich, A. Cummins, S. Kerosky, L. Roche, A. S. Berga, and S. M. Wiggins. (2012). *Passive Acoustic Monitoring for Marine Mammals in the Northwest Training Range Complex 2011* (MPL Technical Memorandum MPL-TM 535). La Jolla, CA: Marine Physical Laboratory, Scripps Institute of Oceanography, University of California San Diego.

Širović, A., S. C. Johnson, L. K. Roche, L. M. Varga, S. M. Wiggins, and J. A. Hildebrand. (2015a). North Pacific right whales (*Eubalaena japonica*) recorded in the northeastern Pacific Ocean in 2013. *Marine Mammal Science, 31*(2), 800–807.

Širović, A., A. Rice, E. Chou, J. A. Hildebrand, S. M. Wiggins, and M. A. Roch. (2015b). Seven years of blue and fin whale call abundance in the Southern California Bight. *Endangered Species Research, 28*, 61–76.

Širović, A., S. Baumann-Pickering, J. A. Hildebrand, A. J. Debich, S. T. Herbert, A. Meyer-Löbbecke, A. Rice, B. Thayre, J. S. Trickey, S. M. Wiggins, and M. A. Roch. (2016). *Passive Acoustic Monitoring for Marine Mammals in the SOCAL Range Complex July 2014–May 2015* (Marine Physical Laboratory Technical Memorandum #607). La Jolla, CA: Marine Physical Laboratory, Scripps Institution of Oceanography, University of California; Department of Computer Science, San Diego State University.

Sivle, L. D., P. H. Kvadsheim, M. A. Ainslie, A. Solow, N. O. Handegard, N. Nordlund, and F. P. A. Lam. (2012a). Impact of naval sonar signals on Atlantic herring (*Clupea harengus*) during summer feeding. *ICES Journal of Marine Science, 69*(6), 1078–1085.

Sivle, L. D., P. H. Kvadsheim, A. Fahlman, F. P. Lam, P. L. Tyack, and P. J. Miller. (2012b). Changes in dive behavior during naval sonar exposure in killer whales, long-finned pilot whales, and sperm whales. *Frontiers in Physiolology, 3*, 400.

Sivle, L. D., P. H. Kvadsheim, and M. A. Ainslie. (2014). Potential for population-level disturbance by active sonar in herring. *ICES Journal of Marine Science, 72*(2), 558–567.

Sivle, L. D., P. H. Kvadsheim, C. Curé, S. Isojunno, P. J. Wensveen, F. A. Lam, F. Visser, L. Kleivane, P. L. Tyack, C. M. Harris, and P. J. O. Miller. (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., P. J. Wensveen, P. H. Kvadsheim, F. P. A. Lam, F. Visser, C. Curé, C. M. Harris, P. L. Tyack, and P. J. O. Miller. (2016). Naval sonar disrupts foraging in humpback whales. *Marine Ecology Progress Series, 562*, 211–220.

Smith, C. E., S. T. Sykora–Bodie, B. Bloodworth, S. M. Pack, T. R. Spradlin, and N. R. LeBoeuf. (2016). Assessment of known impacts of unmanned aerial systems (UAS) on marine mammals: Data gaps and recommendations for researchers in the United States. *Journal of Unmanned Vehicle Systems, 4*(1), 31–44.

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. *The Journal of Experimental Biology, 209*(21), 4193–4202.

Smith, M. E. (2016). Relationship Between Hair Cell Loss and Hearing Loss in Fishes. In A. N. Popper & A. Hawkins (Eds.), *The Effects of Noise on Aquatic Life II* (pp. 8). New York, NY: Springer.

Smultea, M. (2014). Changes in Relative Occurrence of Cetaceans in the Southern California Bight: A Comparison of Recent Aerial Survey Results with Historical Data Sources. *Aquatic Mammals, 40*(1), 32–43.

Smultea, M. A., and J. R. Mobley, Jr. (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*. Pearl Harbor, HI: Naval Facilities Engineering Command Pacific.

Smultea, M. A., J. R. Mobley, Jr., and K. Lomac-MacNair. (2009). *Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with a Navy Training Event, SSC OPS February 15–19, 2009, Final Field Report*. Honolulu, HI: Marine Mammal Research Consultants and Issaquah, WA: Smultea Environmental Sciences, LLC.

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 Oahu, Hawaii. *Pacific Science, 64*(3), 449–457.

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*. Issaquah, WA: Smultea Environmental Sciences.

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*. San Diego, CA: HDR, Inc.

Smultea, M. A., T. A. Jefferson, S. Courbis, G. Campbell, and J. Hopkins. (2015). *Harbor Porpoise Aerial Surveys Conducted in the Strait of Juan de Fuca and San Juan Islands of Washington in Spring 2015. Draft Report*. Preston, WA: Smultea Environmental Sciences, LLC.

Smultea, M. A., K. MacNair-Lomac, G. Campbell, S. Courbis, and T. A. Jefferson. (2017). *Aerial Survey of Marine Mammals Conducted in the Inland Puget Sound Waters of Washington, Summer 2013–Winter 2016. Final Report*. San Diego, CA: Smultea Environmental Sciences, LLC.

Sole, M., P. Sigray, M. Lenoir, M. Van der Schaar, E. Lalander, and M. André. (2017). Offshore exposure experiments on cuttlefish indicate received sound pressure and particle motion levels associated with acoustic trauma. *Scientific Reports, 7*(45899), 1–13.

Soule, D. C., and W. S. D. Wilcock. (2013). Fin whale tracks recorded by seismic network on the Juan de Fuca Ridge, Northeast Pacific Ocean. *The Journal of the Acoustical Society of America, 133*(3), 1–29.

Southall, B., A. Bowles, W. Ellison, J. Finneran, R. Gentry, C. Greene, D. Kastak, D. Ketten, J. Miller, P. Nachtigall, W. Richardson, J. Thomas, and P. Tyack. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals, 33*(4), 122.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, J. Hildebrand, C. Kyburg, R. Carlson, A. Friedlaender, E. Falcone, G. Schorr, A. Douglas, S. DeRuiter, J. Goldbogen, and J. Barlow. (2011). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2010 ("SOCAL-10") Project Report*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, A. Friedlaender, S. DeRuiter, J. Goldbogen, E. Falcone, G. Schorr, A. Douglas, A. K. Stimpert, J. Hildebrand, C. Kyburg, R. Carlson, T. Yack, and J. Barlow. (2012). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2011 ("SOCAL-11") Final Project Report*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

Southall, B., J. Calambokidis, J. Barlow, D. Moretti, A. Friedlaender, A. Stimpert, A. Douglas, K. Southall, S. Arranz, S. DeRuiter, E. Hazen, J. Goldbogen, E. Falcone, and G. Schorr. (2013). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2012 ("SOCAL-12") Final Project Report*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

Southall, B., J. Calambokidis, J. Barlow, D. Moretti, A. Friedlaender, A. Stimpert, A. Douglas, K. Southall, P. Arranz, S. DeRuiter, J. Goldbogen, E. Falcone, and G. Schorr. (2014). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2013 ("SOCAL-13") Final Project Report*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

Southall, B., J. Calambokidis, D. Moretti, A. Stimpert, A. Douglas, J. Barlow, R. W. Rankin, K. Southall, A. Friedlaender, E. Hazen, J. Goldbogen, E. Falcone, G. Schorr, G. Gailey, and A. Allen. (2015). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2014 ("SOCAL-14") Final Project Report*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

Southall, B. L., R. J. Schusterman, and D. Kastak. (2000). Masking in three pinnipeds: Underwater, low-frequency critical ratios. *The Journal of the Acoustical Society of America, 108*(3), 1322–1326.

Southall, B. L., R. J. Schusterman, and D. Kastak. (2003). Auditory masking in three pinnipeds: Aerial critical ratios and direct critical bandwidth measurements. *The Journal of the Acoustical Society of America, 114*(3), 1660–1666.

Southall, B. L., P. L. Tyack, D. Moretti, C. Clark, D. Claridge, and I. Boyd. (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, 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.

Spiesberger, J. L., and K. M. Fristrup. (1990). Passive localization of calling animals and sensing of their acoustic environment using acoustic tomography. *The American Naturalist, 135*(1), 107–153.

St. Aubin, D., and L. A. Dierauf. (2001). Stress and Marine Mammals. In L. A. Dierauf & F. M. D. Gulland (Eds.), *Marine Mammal Medicine* (2nd ed., pp. 253–269). Boca Raton, FL: CRC Press.

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), 1–13.

Sterling, J. T., A. M. Springer, S. J. Iverson, S. P. Johnson, N. A. Pelland, D. S. Johnson, M. A. Lea, and N. A. Bond. (2014). The sun, moon, wind, and biological imperative-shaping contrasting wintertime migration and foraging strategies of adult male and female northern fur seals (*Callorhinus ursinus*). *PLoS ONE, 9*(4), e93068.

Stewart, B. S., and H. R. Huber. (1993). *Mirounga angustirostris*. *Mammalian Species, 449*, 1–10.

Stewart, B. S., and R. L. DeLong. (1995). Double migrations of the northern elephant seal, *Mirounga angustirostris*. *Journal of Mammalogy, 76*(1), 196–205.

Stimpert, A. K., D. N. Wiley, W. W. 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.

Stimpert, A. K., S. L. DeRuiter, B. L. Southall, D. J. Moretti, E. A. Falcone, J. A. Goldbogen, A. Friedlaender, G. S. Schorr, and J. Calambokidis. (2014). Acoustic and foraging behavior of a Baird's beaked whale, *Berardius bairdii,* exposed to simulated sonar. *Scientific Reports, 4*, 7031.

Straley, J. M., G. S. Schorr, A. M. Thode, J. Calambokidis, C. R. Lunsford, E. M. Chenoweth, V. M. O'Connell, and R. D. Andrews. (2014). Depredating sperm whales in the Gulf of Alaska: local habitat use and long distance movements across putative population boundaries. *Endangered Species Research, 24*(2), 125–135.

Sumich, J. L., and I. T. Show. (2011). Offshore migratory corridors and aerial photogrammetric body length comparisons of southbound gray whales, *Eschrichtius robustus*, in the Southern California Bight, 1988–1990. *Marine Fisheries Review, 73*(1), 28–34.

Supin, A. Y., V. V. Popov, and A. M. Mass. (2001). *The Sensory Physiology of Aquatic Mammals*. Boston, MA: Kluwer Academic Publishers.

Suzuki, S., K. Sekiguchi, Y. Mitani, H. Onishi, and T. Kamito. (2016). Distribution of Dall's Porpoise, *Phocoenoides dalli*, in the North Pacific and Bering Sea, Based on T/S Oshoro Maru 2012 Summer Cruise Data. *Zoological Science, 33*(5), 491–496.

Swartz, S. L., B. L. Taylor, and D. J. Rugh. (2006). Gray whale, *Eschrichtius robustus,* population and stock identity. *Mammal Review, 36*(1), 66–84.

Sweeney, K. L., V. T. Helker, W. L. Perryman, D. J. LeRoi, L. W. Fritz, T. S. Gelatt, and R. P. Angliss. (2015). Flying beneath the clouds at the edge of the world: Using a hexacopter to supplement abundance surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska. *Journal of Unmanned Vehicle Systems, 4*(1), 70–81.

Swisdak, M. M., Jr., and P. E. Montanaro. (1992). *Hazards from Underwater Explosions*. Silver Spring, MD: Naval Surface Warfare Center.

Techer, D., S. Milla, and D. Banas. (2017). Sublethal Effect Assessment of a Low-power and Dual-frequency Anti-cyanobacterial Ultrasound Device on the Common Carp (*Cyprinus carpio*): A Field Study. *Environmental Science and Pollution Research 24*, 5669–5678.

Teilmann, J., J. Tougaard, L. A. Miller, T. Kirketerp, K. Hansen, and S. Brando. (2006). Reactions of captive harbor porpoises (*Phocoena phocoena*) to pinger-like sounds. *Marine Mammal Science, 22*(2), 240–260.

Tennessen, J. B., and S. E. Parks. (2016). Acoustic propagation modeling indicates vocal compensation in noise improves communication range for North Atlantic right whales. *Endangered Species Research, 30*, 225–237.

The Northwest Seaport Alliance. (2018). *The Northwest Seaport Alliance 5-Year Cargo Volume History*. Retrieved from https://www.nwseaportalliance.com/sites/default/files/seaport_alliance-5-year_history_feb_17.pdf.

Thomas, J., P. Moore, R. Withrow, and M. Stoermer. (1990a). Underwater audiogram of a Hawaiian monk seal (*Monachus schauinslandi*). *The Journal of the Acoustical Society of America, 87*(1), 417–420.

Thomas, J. A., R. A. Kastelein, and F. T. Awbrey. (1990b). Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. *Zoo Biology, 9*(5), 393–402.

Thompson, D., M. Sjoberg, M. E. Bryant, P. Lovell, and A. Bjorge. (1998). *Behavioral and physiological responses of harbour (Phoca vitulina) and grey (Halichoerus grypus) seals to seismic surveys* (Report to European Commission of BROMMAD Project. MAS2 C7940098). Brussels, Belgium: European Commission.

Thompson, P. M., D. Lusseau, T. Barton, D. Simmons, J. Rusin, and H. Bailey. (2010). Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. *Marine Pollution Bulletin, 60*(8), 1200–1208.

Thompson, P. M., K. L. Brookes, I. M. Graham, T. R. Barton, K. Needham, G. Bradbury, and N. D. Merchant. (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: Biological Sciences, 280*(1771), 20132001.

Titova, O. V., O. A. Filatova, I. D. Fedutin, E. N. Ovsyanikova, H. Okabe, N. Kobayashi, J. M. V. Acebes, A. M. Burdin, and E. Hoyt. (2017). Photo-identification matches of humpback whales (*Megaptera novaeangliae*) from feeding areas in Russian Far East seas and breeding grounds in the North Pacific. *Marine Mammal Science, 34*(1), 100–112.

Tixier, P., N. Gasco, G. Duhamel, and C. Guinet. (2014). Habituation to an acoustic harassment device 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.

Tougaard, J., J. Carstensen, J. Teilmann, N. I. Bech, H. Skov, and O. D. Henriksen. (2005). *Effects of the Nysted Offshore Wind Farm on Harbour Porpoises* (Annual Status Report for the T-POD Monitoring Program). Roskilde, Denmark: National Environmental Research Institute.

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.]). *The Journal of the Acoustical Society of America, 126*(1), 11.

Towers, J. R., C. J. McMillian, M. Malleson, J. Hildering, J. K. B. Ford, and G. M. Ellis. (2013). Seasonal movements and ecological markers as evidence for migration of common minke whales photo-identified in the eastern North Pacific. *Journal of Cetacean Resource Management, 13*(3), 221–229.

Towers, J. R., M. Malleson, C. J. McMillan, J. Cogan, S. Berta, and C. Birdsall. (2018). Occurrence of fin whales (*Balaenoptera physalus*) between Vancouver Island and continental North America. *Northwestern Naturalist, 99*, 49–57.

Trickey, J. S., B. K. Branstetter, and J. J. Finneran. (2010). Auditory masking of a 10 kHz tone with environmental, comodulated, and Gaussian noise in bottlenose dolphins (*Tursiops truncatus*). *The Journal of the Acoustical Society of America, 128*(6), 3799–3804.

Trickey, J. S., S. Baumann-Pickering, A. Širović, J. A. Hildebrand, A. M. Brewer, A. J. Debich, S. Herbert, A. C. Rice, B. Thayre, and S. M. Wiggins. (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.

Trites, A. W., and B. T. Porter. (2002). Attendance patterns of Steller sea lions (*Eumetopias jubatus*) and their young during winter. *Journal of Zoology, London, 256*(4), 547–556.

Trujillo, R. G., T. R. Loughlin, N. J. Gemmell, J. C. Patton, and J. W. Bickham. (2004). Variation in Microsatellites and mtDNA Across the Range of the Steller Sea Lion, *Eumetopias jubatus*. *Journal of Mammalogy, 85*(2), 338–346.

Tyack, P., W. Zimmer, D. Moretti, B. Southall, D. Claridge, J. Durban, C. Clark, A. D'Amico, N. DiMarzio, S. Jarvis, E. McCarthy, R. Morrissey, J. Ward, and I. Boyd. (2011). Beaked Whales Respond to Simulated and Actual Navy Sonar. *PLoS ONE, 6*(3), 15.

Tyack, P. L., M. Johnson, N. Aguilar Soto, A. Sturlese, and P. T. Madsen. (2006). Extreme deep diving of beaked whales. *The Journal of Experimental Biology, 209*, 4238–4253.

U.S. Department of Commerce, and U.S. Department of the Navy. (2001). *Joint Interim Report Bahamas Marine Mammal Stranding Event of 15–16 March 2000*. Washington, DC: Department of Commerce.

U.S. Department of the 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*. Washington, DC: Commander, U.S. Pacific Fleet.

U.S. Department of the Navy. (2008a). *Southern California Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement*. San Diego, CA: Naval Facilities Engineering Command Southwest.

U.S. Department of the Navy. (2008b). *Hawaii Range Complex, Final Environmental Impact Statement/Overseas Environmental Impact Statement*. Pearl Harbor, HI: Hawaii Range Complex.

U.S. Department of the Navy. (2010). *Navy Integrated Comprehensive Monitoring Plan*. Washington, DC: U.S. Department of the Navy.

U.S. Department of the Navy. (2011a). *Scientific Advisory Group for Navy Marine Species Monitoring - Workshop Report and Recommendations*. Washington, DC: U.S. Department of the Navy.

U.S. Department of the Navy. (2011b). *Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2011 Annual Report*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

U.S. Department of the Navy. (2011c). *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)*. Norfolk, VA: United States Fleet Forces Command.

U.S. Department of the 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*. Norfolk, VA: United States Fleet Forces Command.

U.S. Department of the Navy. (2013b). *Comprehensive Exercise and Marine Species Monitoring Report for the U.S. Navy's Hawaii Range Complex 2009–2012*. Pearl Harbor, HI: U.S. Navy Pacific Fleet.

U.S. Department of the Navy. (2013c). *Water Range Sustainability Environmental Program Assessment: Potomac River Test Range*. Dahlgren, VA: Naval Surface Warfare Center.

U.S. Department of the Navy. (2013d). *U.S. Navy Strategic Planning Process for Marine Species Monitoring*. Washington, DC: Chief of Naval Operations, Energy & Environmental Readiness Division.

U.S. Department of the Navy. (2014a). *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*. Silver Spring, MD: National Marine Fisheries Service, Office of Protected Resources.

U.S. Department of the Navy. (2014b). *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*. Norfolk, VA: United States Fleet Forces Command.

U.S. Department of the Navy. (2015a). *Unclassified 2014 Annual Atlantic Fleet Training and Testing (AFTT) Exercise and Testing Report 14 November 2013 to 13 November 2014*. Silver Spring, MD: National Marine Fisheries Service, Office of Protected Resources.

U.S. Department of the Navy. (2015b). *Northwest Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement, Final*. Silverdale, WA: Naval Facilities Engineering Command, Northwest.

U.S. Department of the Navy. (2016). *2015 U.S. Navy Annual Marine Species Monitoring Report for the Pacific: A Multi-Range Complex Monitoring Report for HSTT, MITT, NWTT, GOA TMAA*. Silver Spring, MD: National Marine Fisheries Service Office of Protected Resources.

U.S. Department of the Navy. (2017a). *U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area* (Naval Facilities Engineering Command Pacific Technical Report). Pearl Harbor, HI: Naval Facilities Engineering Command Pacific.

U.S. Department of the Navy. (2017b). *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*. San Diego, CA: Space and Naval Warfare System Command, Pacific.

U.S. Department of the Navy. (2017c). *Navy Sonobuoys Facilitate Endangered Whale Sighting*. Washington, DC: Chief of Naval Operations Energy and Environmental Readiness Division.

U.S. Department of the Navy. (2017d). *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities*. San Diego, CA: U.S. Navy Marine Mammal Program and SPAWAR Naval Facilities Engineering Command.

U.S. Department of the Navy. (2017e). *Dive Distribution and Group Size Parameters for Marine Species Occurring in the U.S. Navy's Atlantic and Hawaii-Southern California Training and Testing Study Areas*. Newport, RI: Naval Undersea Warfare Center Division.

U.S. Department of the Navy. (2017f). *Whale Sightings for Puget Sound Compiled by the U.S. Department of the Navy from the Orca Network webpages for 2003–2017*. Retrieved from http://www.orcanetwork.org/Archives/index.php?categories_file=Sightings%20Archives%20Home.

U.S. Department of the Navy. (2018a). *2017 U.S. Navy Annual Marine Species Monitoring Report for the Pacific: A Multi-Range-Complex Monitoring Report For Hawaii-Southern California Training and Testing (HSTT), Mariana Islands Training and Testing (MITT), Northwest Training and Testing (NWTT), and the Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA)*. Silver Spring, MD: National Marine Fisheries Service.

U.S. Department of the Navy. (2018b). *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Technical Report prepared by NUWC Division Newport, Space and Naval Warfare Systems Center Pacific, G2 Software Systems, and the National Marine Mammal Foundation). Newport, RI: Naval Undersea Warfare Center.

U.S. Department of the Navy. (2019a). *U.S. Navy Marine Species Density Database Phase III for the Northwest Training and Testing Study Area* (Naval Facilities Engineering Command Pacific Technical Report). Pearl Harbor, HI: Naval Facilities Engineering Command Pacific.

U.S. Department of the Navy. (2019b). *Draft Northwest Training and Testing Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement*. San Diego, CA: Naval Facilities Engineering Southwest.

University of Hawaii. (2010). *Hawaii Undersea Military Munitions Assessment, Final Investigation Report HI-05, South of Pearl Harbor, Oahu, HI*. Honolulu, HI: University of Hawaii at Manoa.

Urban-Ramirez, J., L. Rojas-Bracho, H. Perez-Cortes, A. Gomez-Gallardo, S. L. Swartz, S. Ludwig, and R. L. Brownell, Jr. (2003). A review of gray whales (*Eschrichtius robustus*) on their wintering grounds in Mexican waters. *Journal of Cetacean Research and Management, 5*(3), 281–295.

Vallejo, G. C., K. Grellier, E. J. Nelson, R. M. McGregor, S. J. Canning, F. M. Caryl, and N. McLean. (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 Parijs, S. M. (2015). Letter of introduction to the Biologically Important Areas Issue. *Aquatic Mammals, 41*(1), 1–128.

Van Waerebeek, K., A. N. Baker, F. Felix, J. Gedamke, M. Iñiguez, G. P. Sanino, E. Secchi, D. Sutaria, A. van Helden, and Y. Wang. (2007). Vessel collisions with small cetaceans worldwide and with large whales in the southern hemisphere, an initial assessment. *Latin American Journal of Aquatic Mammals, 6*(1), 43–69.

Vancouver Fraser Port Authority. (2017). *Port of Vancouver Statistics Overview 2016*. Vancouver, BC: Decision Support Services.

Vanderlaan, M. S. A., and T. C. Taggart. (2007). Vessel collisions with whales: The probability of lethal injury based on vessel speed. *Marine Mammal Science, 23*(1), 144–156.

Veirs, S., V. Veirs, and J. D. Wood. (2016). Ship noise extends to frequencies used for echolocation by endangered killer whales. *PeerJ, 4*, e1657.

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.

Villadsgaard, A., M. Wahlberg, and J. Tougaard. (2007). Echolocation signals of wild harbour porpoises, *Phocoena phocoena*. *The Journal of Experimental Biology, 210*, 56–64.

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.

Visser, F., C. Cure, P. H. Kvadsheim, F. P. Lam, P. L. Tyack, and P. J. Miller. (2016). Disturbance-specific social responses in long-finned pilot whales, *Globicephala melas*. *Scientific Reports, 6*, 28641.

von Benda-Beckmann, A. M., P. J. Wensveen, P. H. Kvadsheim, F. P. Lam, P. J. Miller, P. L. Tyack, and M. A. Ainslie. (2014). Modeling effectiveness of gradual increases in source level to mitigate effects of sonar on marine mammals. *Conservation Biology, 28*(1), 119–128.

von Benda-Beckmann, A. M., P. J. Wensveen, P. H. Kvadsheim, F. P. A. Lam, P. J. Miller, P. L. Tyack, and M. A. Ainslie. (2016). Assessing the effectiveness of ramp-up during sonar operations using exposure models. In A. N. Popper & A. Hawkins (Eds.), *The Effects of Noise on Aquatic Life II* (pp. 1197–1203). New York, NY: Springer.

Wade, P. R., A. Kennedy, R. LeDuc, J. Barlow, J. Carretta, K. Shelden, W. Perryman, R. Pitman, K. Robertson, B. Rone, J. C. Salinas, A. Zerbini, R. L. Brownell, Jr., and P. J. Clapham. (2010). The world's smallest whale population? *Biology Letters, 7*(1), 83–85.

Wade, P. R., A. De Robertis, K. R. Hough, R. Booth, A. Kennedy, R. G. LeDuc, L. Munger, J. Napp, K. E. W. Shelden, S. Rankin, O. Vasquez, and C. Wilson. (2011). Rare detections of North Pacific right whales in the Gulf of Alaska, with observations of their potential prey. *Endangered Species Research, 13*(2), 99–109.

Wade, P. R., T. J. Quinn, II, J. Barlow, C. S. Baker, A. M. Burdin, J. Calambokidis, P. J. Clapham, E. A. Falcone, J. K. B. Ford, C. M. Gabriele, D. K. Mattila, L. Rojas-Bracho, J. M. Straley, and B. Taylor. (2016). *Estimates of Abundance and Migratory Destination for North Pacific Humpback Whales in Both Summer Feeding Areas and Winter Mating and Calving Areas* (SC/66b/IA/21). Washington, DC: International Whaling Commission.

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, S. W., C. L. Osburn, T. J. Boyd, L. J. Hamdan, R. B. Coffin, M. T. Montgomery, J. P. Smith, Q. X. Li, C. Hennessee, F. Monteil, and J. Hawari. (2006). *Mineralization of 2, 4, 6-Trinitrotoluene (TNT) in Coastal Waters and Sediments*. Washington, DC: U.S. Department of the Navy, Naval Research Laboratory.

Ward, W. D., A. Glorig, and D. L. Sklar. (1958). Dependence of temporary threshold shift at 4 kc on intensity and time. *The Journal of the Acoustical Society of America, 30*(10), 944–954.

Ward, W. D., A. Glorig, and D. L. Sklar. (1959). Relation between recovery from temporary threshold shift and duration of exposure. *The Journal of the Acoustical Society of America, 31*(5), 600–602.

Ward, W. D. (1960). Recovery from high values of temporary threshold shift. *The Journal of the Acoustical Society of America, 32*(4), 497–500.

Wartzok, D., and D. R. Ketten. (1999). Marine Mammal Sensory Systems. In J. E. Reynolds, III & S. A. Rommel (Eds.), *Biology of Marine Mammals* (pp. 117–175). Washington, DC: Smithsonian Institution Press.

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), 6–15.

Washington Department of Fish and Wildlife. (2013). *Threatened and Endangered Wildlife. Annual Report 2012*. Olympia, WA: Washington Department of Fish and Wildlife Listing and Recovery Section, Diversity Division, Wildlife Program.

Wasser, S. K., J. I. Lundin, K. Ayres, E. Seely, D. Giles, K. Balcomb, J. Hempelmann, K. Parsons, and R. Booth. (2017). Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca*). *PLoS ONE, 12*(6), e0179824.

Watkins, W. A., and W. E. Schevill. (1975). Sperm whales (*Physeter catodon*) react to pingers. *Deep-Sea Research, 22*, 123–129.

Watkins, W. A., K. E. Moore, and P. Tyack. (1985). Sperm whale acoustic behavior in the southeast Caribbean. *Cetology, 49*, 1–15.

Watkins, W. A. (1986). Whale reactions to human activities in Cape Cod waters. *Marine Mammal Science, 2*(4), 251–262.

Watwood, S., M. Fagan, A. D'Amico, and T. Jefferson. (2012). *Cruise Report, Marine Species Monitoring and Lookout Effectiveness Study, Koa Kai, November 2011, Hawaii Range Complex*. Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

Watwood, S., E. McCarthy, N. DiMarzio, R. Morrissey, S. Jarvis, and D. Moretti. (2017). *Beaked whale foraging behavior before, during, and after sonar exposure on a Navy test range.* Paper presented at the 22nd Biennial Conference on the Biology of Marine Mammals. Halifax, Canada.

Watwood, S. L., J. D. Iafrate, E. A. Reyier, and W. E. Redfoot. (2016). Behavioral Response of Reef Fish and Green Sea Turtles to Mid-Frequency Sonar. In A. N. Popper & A. Hawkins (Eds.), *The Effects of Noise on Aquatic Life II* (pp. 1213–1221). New York, NY: Springer.

Weaver, A. (2015). Sex difference in bottlenose dolphin sightings during a long-term bridge construction project. *Animal Behavior and Cognition, 2*(1), 1–13.

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.

Weise, M., D. Coasta, and R. Kudela. (2006). Movement and diving behavior of male Calfiornia sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005 compared to those of 2004. *Geophysical Research Letters, 33*, 6.

Weller, D. W., A. M. Burdin, B. Würsig, B. L. Taylor, and R. L. Brownell, Jr. (2002). The western gray whale: A review of past exploitation, current status and potential threats. *Journal of Cetacean Research and Management, 4*(1), 7–12.

Weller, D. W., and R. L. Brownell, Jr. (2012). *A re-evaluation of gray whale records in the western North Pacific* (SC/64/BRG10). La Jolla, CA: Southwest Fisheries Science Center.

Weller, D. W., A. Klimek, A. L. Bradford, J. Calambokidis, A. R. Lang, B. Gisborne, A. M. Burdin, W. Szaniszlo, J. Urbán, A. Gomez-Gallardo Unzueta, S. Swartz, and R. L. Brownell. (2012). Movements of gray whales between the western and eastern North Pacific. *Endangered Species Research, 18*(3), 193–199.

Weller, D. W., S. Bettridge, R. L. Brownell, J. L. Laake, M. J. Moore, P. E. Rosel, B. L. Taylor, and P. R. Wade. (2013). *Report of the National Marine Fisheries Service Gray Whale Stock Identification Workshop* (NOAA Technical Memorandum NMFS-SWFSC-507). La Jolla, CA: Southwest Fisheries Science Center.

Wensveen, P. J., A. M. von Benda-Beckmann, M. A. Ainslie, F. P. Lam, P. H. Kvadsheim, P. L. Tyack, and P. J. Miller. (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., P. H. Kvadsheim, F.-P. A. Lam, A. M. Von Benda-Beckmann, L. D. Sivle, F. Visser, C. Curé, P. Tyack, and P. J. O. Miller. (2017). Lack of behavioural responses of humpback whales (*Megaptera novaeangliae*) indicate limited effectiveness of sonar mitigation. *The Journal of Experimental Biology, 220*, 1–12.

Whitehead, H., and L. Weilgart. (2000). The sperm whale; Social females and roving males. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), *Cetacean Societies; Field Studies of Dolphins and Whales* (pp. 154–172). Chicago, IL: University of Chicago Press.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau. (2008). Movements of sperm whales in the tropical Pacific. *Marine Ecology Progress Series, 361*, 291–300.

Whitehead, P. G., R. L. Wilby, R. W. Battarbee, M. Kernan, and A. J. Wade. (2009). A review of the potential impacts of climate change on surface water quality. *Hydrological Sciences Journal, 54*(1), 101–123.

Wiggins, S. M., A. J. Debich, J. S. Trickey, A. C. Rice, B. J. Thayre, S. Baumann-Pickering, A. Sirovic, and J. A. Hildebrand. (2017). *Summary of Ambient and Anthropogenic Sound in the Gulf of Alaska and Northwest Coast* (MPL Technical Memorandum #611). La Jolla, CA: Marine Physical Laboratory.

Wiles, G. J. (2015). *Periodic Status Review for the Steller Sea Lion*. Olympia, WA: Washington Department of Fish and Wildlife.

Wiles, G. J. (2016). *Periodic Status Review for the Killer Whale*. Olympia, WA: Washington Department of Fish and Wildlife.

Wiley, D. N., C. A. Mayo, E. M. Maloney, and M. J. Moore. (2016). Vessel strike mitigation lessons from direct observations involving two collisions between noncommercial vessels and North Atlantic right whales (*Eubalaena glacialis*). *Marine Mammal Science, 32*(4), 1501–1509.

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., D. Lusseau, and P. S. Hammond. (2006). Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). *Biological Conservation, 133*, 301–311.

Williams, R., and L. Thomas. (2007). Distribution and abundance of marine mammals in the coastal waters of British Columbia, Canada. *Journal of Cetacean Research and Management, 9*(1), 15–28.

Williams, R., D. E. Bain, J. C. Smith, and D. Lusseau. (2009). Effects of vessels on behaviour patterns of individual southern resident killer whales, *Orcinus orca*. *Endangered Species Research, 6*, 199–209.

Williams, R., C. W. Clark, D. Ponirakis, and E. Ashe. (2014a). Acoustic quality of critical habitats for three threatened whale populations. *Animal Conservation, 17*(2), 174–185.

Williams, R., C. Erbe, E. Ashe, A. Beerman, and J. Smith. (2014b). Severity of killer whale behavioral responses to ship noise: A dose-response study. *Marine Pollution Bulletin, 79*(1–2), 254–260.

Williams, R., S. Veirs, V. Veirs, E. Ashe, and N. Mastick. (2019). Approaches to reduce noise from ships operating in important killer whale habitats. *Marine Pollution Bulletin, 139*, 459–469.

Williams, T. M., T. L. Kendall, B. P. Richter, C. R. Ribeiro-French, J. S. John, K. L. Odell, B. A. Losch, D. A. Feuerbach, and M. A. Stamper. (2017). Swimming and diving energetics in dolphins: A stroke-by-stroke analysis for predicting the cost of flight responses in wild odontocetes. *The Journal of Experimental Biology, 220*(6), 1135–1145.

Willis, P. M., and R. W. Baird. (1998a). Status of the Dwarf Sperm Whale. *Kogia simus*, with Special Reference to Canada. *Canadian Field-Naturalist, 112*(1), 114–125.

Willis, P. M., and R. W. Baird. (1998b). Sightings and strandings of beaked whales on the west coast of Canada. *Aquatic Mammals, 24*(1), 21–25.

Withrow, D. E., J. C. Cesarone, and J. L. Bengtson. (1999). Abundance and distribution of harbor seals (*Phoca vitulina richardsi*) for southern Southeast Alaska from Frederick Sound to the US/Canada border in 1998. In A. L. Lopez & D. P. DeMaster (Eds.), *Marine Mammal Protection Act and Endangered Species Act Implementation Program 1998*. Silver Spring, MD: National Marine Fisheries Service Office of Protected Resources.

Womble, J. N., and S. M. Gende. (2013). Post-breeding season migrations of a top predator, the harbor seal (Phoca vitulina richardii), from a marine protected area in Alaska. *PLoS ONE, 8*(2), e55386.

Womble, J. N., G. W. Pendleton, E. A. Mathews, and S. M. Gende. (2015). *Status and Trend of Harbor Seals (Phoca vitulina richardii) at Terrestrial Sites in Glacier Bay National Park from 1992–2013. Progress Report*. Juneau, AK: National Park Service and the Alaska Department of Fish & Game.

Wright, B., T. Murtagh, R. Brown, and S. Riemer. (2017a). *Willamette Falls Pinniped Monitoring Project, 2017*. Oregon City, OR: Oregon Department of Fish and Wildlife.

Wright, B. E., M. J. Tennis, and R. F. Brown. (2010). Movements of Male California Sea Lions Captured in the Columbia River. *Northwest Science, 84*(1), 60–72.

Wright, B. M., J. K. B. Ford, G. M. Ellis, V. B. Deecke, A. D. Shapiro, B. C. Battaile, and A. W. Trites. (2017b). Fine-scale foraging movements by fish-eating killer whales (*Orcinus orca*) relate to the vertical distributions and escape responses of salmonid prey (*Oncorhynchus* spp.). *Movement Ecology, 5*(3), 1–18.

Wright, D. G. (1982). *A Discussion Paper on the Effects of Explosives on Fish and Marine Mammals in the Waters of the Northwest Territories* (Canadian Technical Report of Fisheries and Aquatic Sciences). Winnipeg, Canada: Western Region Department of Fisheries and Oceans.

Wright, D. L., C. L. Berchok, J. L. Crance, and P. J. Clapham. (In press). Acoustic detection of the critically endangered North Pacific right whale in the northern Bering Sea. *Marine Mammal Science*.

Yack, T. M., T. F. Norris, and N. Novak. (2016). *Acoustic Based Habitat Models for Sperm Whales in the Mariana Islands Region*. Encinitas, CA: Bio-Waves, Inc.

Yamada, T. K., Y. Tajima, A. Yatabe, B. M. Allen, and R. L. Brownell, Jr. (2012). *Review of Current Knowledge on Hubbs' Beaked Whale, Mesoplodon carlhubbsi, From the Seas Around Japan and Data From the North America* (SC/64/SM27). Ibaraki, Japan: National Museum of Nature and Science, Tokyo University of Marine Science and Technology, Alaska Fisheries Science Center, and Southwest Fisheries Science Center.

Yazvenko, S. B., T. L. McDonald, S. A. Blokhin, S. R. Johnson, H. R. Melton, M. W. Newcomer, R. Nielson, and P. W. Wainwright. (2007). Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. *Environmental Monitoring and Assessment, 134*(1–3), 93–106.

Yelverton, J. T., D. R. Richmond, E. R. Fletcher, and R. K. Jones. (1973). *Safe Distances From Underwater Explosions for Mammals and Birds*. Albuquerque, NM: Lovelace Foundation for Medical Education and Research.

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*. Albuquerque, NM: Defense Nuclear Agency.

Yuen, M. M. L., P. E. Nachtigall, M. Breese, and A. Y. Supin. (2005). Behavioral and auditory evoked potential audiograms of a false killer whale (*Pseudorca crassidens*). *The Journal of the Acoustical Society of America, 118*(4), 2688–2695.

Zerbini, A. N., J. M. Waite, J. L. Laake, and P. R. Wade. (2006). Abundance, trends and distribution of baleen whales off Western Alaska and the central Aleutian Islands. *Deep-Sea Research Part I, 53*, 1772–1790.

Zerbini, A. N., P. J. Clapham, and M. P. Heide-Jørgensen. (2010). *Migration, wintering destinations and habitat use of North Pacific right whales (Eubalaena japonica)* (North Pacific Research Board: Project 720-Final Report). Seattle, WA: National Marine Mammal Laboratory, Greenland Institute of Natural Resources.

Zerbini, A. N., M. F. Baumgartner, A. S. Kennedy, B. K. Rone, P. R. Wade, and P. J. Clapham. (2015). Space use patterns of the endangered North Pacific right whale *Eubalaena japonica* in the Bering Sea. *Marine Ecology Progress Series, 532*, 269–281.

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., M. A. Smultea, A. S. Frankel, J. L. Hopkins, A. Day, and A. S. McFarland. (2008). Vocalizations produced by humpback whale (*Megaptera novaeangliae*) calves recorded in Hawaii. *The Journal of the Acoustical Society of America, 123*(3), 1737–1746.